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ORIGINAL RESEARCH PAPER

DOES KNEE EXTENSORS AND FLEXORS MUSCLE STRENGTH AND STRENGTH BALANCE DIFFER BY PLAYING POSITION OF SOCCER PLAYERS?

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Abstract

The purpose of this study is to compare the strength and muscle balance of peak torque of knee extensors and flexors of soccer players according to playing positions. The strength parameters consist of absolute and relative strength, and muscle balance parameters of bilateral strength balance and H/Q ratio of dominant and non-dominant leg. The participants of this study are 102 male soccer players of Estonian Premium League teams: 41 defenders, 40 midfielders and 21 forwards. Muscle strength is measured in the isokinetic concentric mode at angular velocities of 60 and 300°/s and in the eccentric mode at 60°/s (Humac Norms). The one-way ANOVA and Bonferroni methods are used to compare strength parameters between positions. The Student t-test is used to compare dominant and non-dominant leg within the playing position groups. We find that absolute peak torque values of midfielders are statistically significantly smaller than defenders and forwards at angular velocity 60°/s on concentric and eccentric mode. No statistically significant differences are found between soccer players' positions at angular speed 300°/s. We find that relative peak torque does not differ statistically significantly between players position. Defenders have statistically significantly stronger dominant leg compared to non-dominant leg in the concentric and eccentric mode at angular velocity 60°/s. No statistically significant differences are found between playing positions in bilateral strength balance and H/Q ratio. Players in

different playing position have different knee extensors and flexors strength values, but no differences are observed between playing position and knee extensors and flexors strength balance.

Keywords: *soccer, isokinetic, strength, bilateral, H/Q ratio, asymmetry.*

Introduction

Playing in different positions demands different anthropometrics and physical abilities (Tourny-Chollet et al., 2000, Bloomfield et al., 2007). Defenders cover a shorter distance in high-intensity running (Mohr et al., 2003) and their bilateral deficit of muscle strength is the lowest compared to players in other positions (Tourny-Chollet et al., 2000). Defenders are taller and heavier than midfielders and forwards, taller players are most suitable for playing in central defensive position. (Tourny-Chollet et al., 2000; Reily et al., 2000). Midfield players have the lightest weight (Tourny-Chollet et al., 2000), cover the longest distance during the match (Bangsbo et al., 1991, Mohr et al., 2003, Di Salvo et al., 2007), their VO2 max is the highest (Reilly et al. 2000), they have lower muscle strength (Thourny-Collet et al., 2000; Reilly et al. 2000) and their jumping height is lower compared to players in other positions (Haugen et al., 2013). Forwards are taller and heavier than defenders and midfielders (Nikolaidis et al., 2014), fastest and jump higher (Gil et al., 2007, Haugen et al., 2013), they have greater muscular strength (Tourny-Chollet et al., 2000) and they cover longer distance in high intensity, than players in other positions (Gil et al., 2007).

Muscle strength of the lower extremities is the key factor in many sports disciplines, including soccer (Lehance et al., 2009). The quadriceps muscle is important in kicking, jumping and running (Kary, 2010). Hamstring muscles is important in soccer players for stabilizing joints (Aagard 1998, Cometti, 2001). Very often there are muscular asymmetries of lower extremities observed in soccer players (Dauty et. al., 2003, Fousekis et al., 2010, Lehance et al., 2009, Rahnama et al., 2005, Daneshjoo et al., 2013). Problems in the muscular bilateral strength of knee extensors and flexors appear in 56-97% of soccer players (Lehance et al., 2009, Rahnama et al., 2005, Daneshjoo et al., 2013). Functional asymmetry may cause performance reduction and may increase the risk of injury (Fousekis et al., 2010, Jones et al., 2010). Playing position is one out of five factors that affect functional asymmetry (Fousekis et al., 2010). There are many previous studies about isokinetic strength parameters of soccer players at top level (Eniseler et al., 2012, Fousekis et al., 2010, Dauty et al., 2003, Fonseca et al., 2007, Croisier et al., 2008, Geofitsidou et al., 2008, Cotte et al., 2011), differences between various performance levels (Papaevangelou et al., 2012, Cometti et al., 2001) and differences between age (Andrade et

al., 2012; Lehance et al., 2009, Kellis et al., 2001, Gür et al., 1999). But there are only a few studies on differences between playing positions (Tourny-Chollet et al., 2000; Ruas et al., 2015). Tourny-Chollet et al. (2000) find that midfielders' knee muscles relative peak torque was statistically significantly lower in concentric mode, but there are no differences in eccentric mode. Ruas and co-authors (2015) find that forwards and goalkeepers have hamstrings' concentric and eccentric peak torque asymmetry significantly greater than 10%.

The purpose of this study is to compare knee extensors and flexors absolute and relative peak torque; and bilateral strength balance and H/Q ratio of soccer players according to playing positions.

Material and methods

All procedures described in the study were approved by the National Institute for Health Development of Estonia.

*Participants.*The participants of this study are 102 male soccer players of professional Estonian Premium League teams: 41 defenders, 40 midfielders and 21 forwards. All athletes were physically healthy and were ready to perform maximum performance. All athletes participated in the study voluntarily.

Instrumentation and procedures. The athletes were measured and weighed at the beginning of the study. After that, athletes made a warm up program: 5 minutes riding the veloergometer and 5 minutes individual stretching exercises. This was followed by the knee extensor and flexor muscles strength testing by isokinetic dynamometer (Humac Norms). The dynamometer set according to the manufacturers' instructions, was used at a sitting position where back angle was 85°. Muscle strength was measured in the isokinetic concentric mode at angular velocities of 60 and 300°/s and in the eccentric mode at 60°/s. Athletes completed three different types of tests. Before each type of test there was a trial testing, in which the athletes could exercise in performing the movement. There was a two minute pause after the trial and a three minute pause between the tests. There was a five minute pause between the tests of different body side. Testing order of body sides was randomized. During the trial testing and control testing they made five concentric repetitions at 300°/s, three concentric repetitions at 60°/s and three eccentric repetitions at 60°/s. The best result of all repetitions is taken for the statistical analysis of this paper.

Measures. The following parameters are measured in this study:

- Absolute peak torque (Nm)
- Relative peak torque (Nm/kg)

-The strength difference (bilateral symmetry) between dominant and non-dominant leg is quantified with absolute symmetry index (ASI) – (ASI=|D-ND|/max[D;ND])

-Unilateral strength balance is measured as hamstring and quadriceps strength ratio in %.

Analysis. Absolute and relative peak torque of dominant and non-dominant leg, muscle groups' bilateral muscle strength values and H/Q ratios are compared between defenders, midfielders and forwards using ANOVA. The differences between the dominant and non-dominant leg by position groups are tested with the Student t-test for paired data. These tests estimate the existence of systematic body side differences in different playing positions. The statistically significant difference criterion is determined as p value smaller than 0.05 and Cohen d value at least 0.20. The size of the effect is interpreted as follows: 0.20, 0.60, 1.2, 2.0 and 4.0 for respectively small, moderate, large, very large and extremely large (Hopkins, 2010).

Results

The anthropometry of soccer players according to their playing position is statistically significantly different (Table 1).

Table 1

Comparison of age and anthropometry of soccer players according to playing position

	Total	Defenders	Midfielders	Forwards	ANOVA probability of significance
Age	22.9±4.4	23.4±4.6	22.2±4.0	23.2±4.5	0.432
Height	181.1±6.7	182.7±7.2[b]	178.1±5.7[a,c]	183.7±5.4[b]	0.001
Body mass	76.6±8.2	78.5±8.1[b]	72.7±6.5[a,c]	80.1±8.6[b]	0.000

a-statistical difference from defenders; b-statistical difference from midfielders; c-statistical difference from forwards.

No differences are found between the ages of soccer players according their playing position. Midfielders are shorter and lighter than defenders and forwards with moderate effect size.

Table 2 presents the results of absolute peak torque of soccer players according to their playing positions.

Table 2

Comparisons of knee extensors and flexors absolute peak torque of the dominant (D) and non-dominant (ND) leg of soccer players according to playing position

Action	Defenders (n=40)	Midfielders (n=41)	Forwards (n=21)	ANOVA probability of significance
Extensors con 300°/s D	127.1±18.8	124.2±19.7	130.2±17.8	0.489
Extensors con 300°/s ND	128.2±20.2	124.0±16.0	130.4±18.8	0.370
Flexors con 300°/s D	82.0±14.4	81.3±13.4	87.3±14.8	0.258
Flexors con 300°/s ND	79.1±15.5	79.7±13.1	86.5±13.9	0.134
Extensors con 60°/s D	246.4± 37.0[b]	220.1±41.5[ac]	248.1±36.6[b]	0.004
Extensors con 60°/s ND	240.0± 33.8[b]	218.6±36.7[ac]	253.5±35.3[b]	0.001
Flexors con 60°/s D	156.6±27.4[b#]	137.9±24.7[ac]	162.3±30.4[b]	0.001
Flexors con 60°/s ND	149.4±25.4	137.0±23.5[c]	155.4±24.0[b]	0.011
Extensors ecc 60°/s D	309.7±50.8[b]	265.4±61.5[ac]	316.2±55.6[b]	0.001
Extensors ecc 60°/s ND	300.6±47.1[b]	267.7±56.5[ac]	309.6±57.8[b]	0.005
Flexors ecc 60°/s D	185.5±37.0 [#]	164.4±40.7	184.3±38.7	0.042
Flexors ecc 60°/s ND	173.7±32.9	160.4±33.8	177.2±41.1	0.133

a-statistically significant difference from defenders; b-statistically significant difference from midfielders; c-statistically significant difference from forwards; # statistically significant difference from non-dominant leg.

Midfielders absolute peak torque of extensors are smaller than defenders (p=0.009; d=0.67) and forwards (p=0.026; d=0.72) at angular velocity 60°/s in concentric mode of dominant leg. Similar results are revealed on non-dominant leg, where midfielders' absolute peak torque of extensors is smaller than defenders (p=0.023; d=0.61) and forwards (p=0.001; d=0.97) at angular velocity 60°/s in concentric mode. Midfielders absolute peak torque of flexors is smaller than defenders (p=0,007; d=0.72) and forwards (p=0,003; d= 0.89) at angular velocity 60°/s in concentric mode of dominant leg. Midfielders' absolute peak torque of flexors is smaller than forwards (p=0,018; d=0.77) for non-dominant leg.

The tests in eccentric mode revealed similar results as in concentric mode for extensors. Midfielders absolute peak torque of extensors are smaller than defenders (p=0.003; d= 0.79) and forwards (p= 0.004; d= 0.84) for dominant leg. There is the same differences between positions for non-dominant leg, midfielders' absolute peak torque of extensors is smaller than defenders (p=0.025; d=0.64) and forwards (p=0.014; d=0.73). No statistically significant differences are found between playing positions of soccer players at angular velocity 300°/s.

There are no statistically significant differences between dominant and non-dominant leg in most cases. Only defenders have stronger flexors

of dominant leg compared to non-dominant leg at angular velocity 60°/s concentrically (p=0.013; d=0.27) and eccentrically (p=0.011; d=0.34).

Table 3 presents the results of relative peak torque of soccer players according to their playing positions.

Table 3

Comparisons of knee extensors and flexors relative peak torque of the dominant and non-dominant leg of soccer players according to playing position

Action	Defenders (n=37)	Midfielders (n=39)	Forwards (n=21)	ANOVA probability of significance
Extensors con 300°/s D	1.62±0.18	1.71±0.23	1.62±0.12	0.078
Extensors con 300°/s ND	1.63±0.19	1.71±0.17	1.63±0.16	0.119
Flexors con 300°/s D	1.04±0.15	1.12±0.15	1.09±0.15	0.094
Flexors con 300°/s ND	1.02±0.15	1.10±0.14	1.09±0.14	0.055
Extensors con 60°/s D	3.14±0.39	3.02±0.43	3.09±0.30	0.348
Extensors con 60°/s ND	3.06±0.34	3.00±0.40	3.16±0.23	0.262
Flexors con 60°/s D	1.99±0.27 #	1.90±0.29	2.03±0.34	0.169
Flexors con 60°/s ND	1.90±0.25	1.88±0.25	1.95±0.28	0.634
Extensors ecc 60°/s D	3.96±0.59	3.63±0.74	3.82±0.66	0.064
Extensors ecc 60°/s ND	3.84±0.57	3.66±0.64	3.77±0.59	0.324
Flexors ecc 60° D	2.36±0.41 #	2.25±0.50	2.31±0.46	0.584
Flexors ecc 60° ND	2.21±0.37	2.20±0.40	2.21±0.40	0.972

statistically significant difference from non-dominant leg.

No statistically significant differences are found in relative peak torque of knee extensors and flexors by playing position of soccer players. Differences were found only between dominant and non-dominant leg in flexors of defenders, where dominant leg has higher peak torque than non-dominant leg in concentric mode (p=0.012; d=0.35) and in eccentric mode (p=0.010; d=0.38)

Table 4 shows soccer players knee extensors and flexors peak torque deficit between legs by playing position.

Table 4

Comparisons of soccer players knee extensors and flexors peak torque deficit between legs by playing position

Action	Defenders (n=37)	Midfielders (n=39)	Forwards (n=21)	ANOVA probability of significance
Extensors con 300° DEF	6.4±6.0	5.8±4.8	5.5±3.8	0.783
Flexors con 300° DEF	5.6±18.4	2.4±9.4	1.7±14.7	0.506
Extensors con 60° DEF	8.6±5.9	9.5±6.9	7.7±6.9	0.569
Flexors con 60° DEF	10.6±7.7	8.9±7.7	8.6±6.8	0.496
Extensors ecc 60° DEF	8.6±7.2	11.1±9.4	11.6±7.9	0.302
Flexors ecc 60° DEF	12.6±9.1	10.8±10.1	11.5±6.7	0.718

No statistically significant differences are found in bilateral deficit of soccer players according to their playing position. No statistically significant differences are found also between knee extensors and flexors deficit by playing position. It is observed that the standard deviations of these indicators are large, especially for knee flexors.

Table 5 is showing the results of H/Q ratios of the dominant and non-dominant leg of soccer players by playing position.

Table 5

Comparisons of H/Q ratio of the dominant and non-dominant leg of soccer players according playing position

Action	Defenders (n=37)	Midfielders (n=39)	Forwards (n=21)	ANOVA probability of significance
Hcon/Qcon 300 ratio D	0.65±0.08	0.66±0.08	0.67±0.08	0.523
Hcon/Qcon 300 ratio ND	0.63±0.09	0.64±0.08	0.67±0.09	0.197
Hcon/Qcon 60 ratio D	0.64±0.09	0.63±0.09	0.66±0.10 #	0.639
Hcon/Qcon 60 ratio ND	0.64±0.08	0.63±0.08	0.62±0.09	0.849
Hecc/Qecc 60 ratio D	0.60±0.09	0.64±0.1	0.61±0.1	0.173
Hecc/Qecc 60 ratio ND	0.58±0.10	0.60±0.08	0.60±0.08	0.536
Hecc/Qcon 60 ratio D	0.76±0.12	0.76±0.16	0.77±0.13	0.947
Hecc/Qcon 60 ratio ND	0.73±0.13	0.76±0.14	0.72±0.12	0.529

statistically significant difference from non-dominant leg

No statistically significant differences are found between soccer players and playing positions in H/Q ratio. Statistically significant differences are found between dominant and non-dominant leg in H/Q ratio of forwards, where H/Q ratio of dominant leg was higher.

Discussion

The purpose of this study is to compare knee muscle strength and muscle strength balance of soccer players playing in different positions. The following strength parameters are compared: knee extensors and flexors absolute and relative peak torque, bilateral strength balance and H/Q ratio. There are specific demands for players in different positions during the soccer matches (Bangsbo et al., 1991, Mohr et al., 2003, Di Salvo et al., 2007) and depending on this players with different specialities may have different morpho-functional properties (Bloomfield et al., 2007). We find differences between soccer players of different playing position in anthropometrical characteristics such as body height and mass. Findings of this study are well in line with the previous study where the midfield players were lighter and defenders were heavier and taller than other players

(Tourny-Chollet et al., 2000; Hencken & White, 2006; Haugen, 2013, Nikolaidis et al., 2014).

We find also some differences between player positions in absolute strength level (measured as peak torque), but no differences in strength values normalized with body mass. The findings of our study are partly in line with the previous study by Tourny-Chollet et al. (2010) that finds that midfielders' relative peak torque values in low angular speed (60°/s) are statistically significantly lower than the values of defenders and attackers. Our study does not find any differences between playing positions in relative peak torque, but we find that midfielders have statistically significantly lower absolute peak torque values than players at other positions. Like in previous study we find the same result in high angular velocities (240° and 300°), there are no statistically significant differences between relative peak torque values for players from different position.

The skill of two-footed play and asymmetrical musculoskeletal loading is causing functional asymmetry which is related to larger injury risk (Brady et al., 2001, Fousekis et al., 2010). Study by Tourny-Chollet et al. (2000) finds that hamstring muscles of midfielder and forward dominant leg are statistically significantly stronger than the non-dominant leg in concentric mode. No statistically significant differences between playing positions are found for extensors in eccentric mode. These findings are partly in line with findings of our study. We find also that the extensors of the dominant leg are statistically significantly stronger than the extensors of the non-dominant leg at low angular speed (60°). Like in previous study we do not find any differences in extensors.

The main difference between previous study and this one is that we find differences for the group of defenders. Results of our study are supported by previous study (Fonseca et al., 2007) where no statistically significant differences are found between dominant and non-dominant leg extensors, but statistically significant differences are revealed between knee flexors. Knee flexors of the dominant leg are stronger than those of the non-dominant leg. The probable reason why the dominant leg is stronger than the non-dominant leg is that soccer players are using their dominant leg more for shooting and passing. Knee flexors have to slow the limb down at the end of the shooting and passing movement, where they are working in eccentric mode. We find more differences between the dominant and the non-dominant leg eccentric mode, Cohen d values are higher in the eccentric mode compared to the concentric mode. There are some reasons why the differences between dominant and non-dominant leg revealed only among defenders. They play soccer using their dominant leg most of the time; they are holding a ball on a side where they are playing. The second reason can

be that defenders have to often do long passes and crosses, and they are using the dominant leg for these activities.

The results described above show that only defenders had some direction specific differences between the dominant and the non-dominant leg, but the results of absolute and non-directional symmetry between body sides have not been discussed. Results of this study are not in line with the previous study by Ruas et al. (2015) where they find statistically significant differences between muscular asymmetry and playing position. This previous study finds that forwards have statistically significantly higher hamstring muscles asymmetry than defenders and midfielders. Our study does not reveal any differences between playing positions in bilateral symmetry. There are many authors who find that if the bilateral asymmetry is more than 10% (Fonseca et al., 2010, Rahnama et al., 2005, Daneshjoo et al., 2013) or 15% (Croisier et al., 2003; Geofitsidou et al., 2003) it reduces performance and increases the risk of injury. Soccer players with untreated strength imbalances before the season had significantly higher rate of muscle injury than players with no imbalances (Croisier et al., 2008). We do not find statistically significant differences between playing positions in bilateral strength deficit. We find that the average bilateral deficit value is around 10%, which is in the same magnitude as in the previous study (Ruas et al., 2015). We observe the smallest differences between the dominant and the non-dominant leg at 300°/s (1.7-6.4 %), while the largest differences between the dominant and the non-dominant leg are at angular velocity 60 °/s, ranging between 7.7% and 12.6%. One reason why soccer players bilateral deficit is not statistically significantly different between playing positions is that the nowadays soccer is a very dynamic game, more or less all players are dealing with attacking and defending. For example, side backs are defence players, but they turn on to attacks more often.

It is well known that the balance between hamstring and quadriceps, like bilateral asymmetry discussed above, is important for preventing non-contact injuries. Most common H/Q ratio value is 0.6 at angular velocity 60°, which is a "normal" value (Coombs & Garbutt, 2002; Fonseca et al., 2007). Previous studies find that mixed H/Q ratio (eccentric flexors and concentric quadriceps) less than 0.8 refers to muscular abnormalities; and mixed ratio lower than 0.6 is the best predictor of previous hamstring injuries (Croisier et al., 2003, Dauty et al., 2003). The average value of H/Q ratios is more than 0.6 in this study in both concentric and eccentric mode, but mixed ratio is lower than 0.8. We find no statistically significant differences between playing position in H/Q ratio. Statistically significant differences are revealed only between the dominant and the non-dominant leg H/Q ratio for forwards, where the ratio was higher in dominant leg. The reason why

forwards dominant leg H/Q ratio is higher than the non-dominant leg H/Q ratio can be that soccer players are using their dominant leg for most cases like set piece and shot to the goal in training and in competitions (Carey, et al. 2001) and this is more common for forwards. The mechanism is the same as we describe above, the hamstring muscles have to decelerate the leg at the end of movements; and that is why the hamstring muscles get the load that makes these stronger and the H/Q ratio higher.

In sum, we can say that midfielders have lower absolute strength level that at least partly is related with their lower body mass. We find no players' position specific differences in muscle balance parameters, while defenders have stronger dominant side and have direction-specific differences in knee flexors strength at lower testing speeds in concentric and eccentric mode. We find also that forwards demonstrated higher unilateral strength balance of the dominant leg in low concentric speed.

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ORIGINAL RESEARCH PAPER

SELF-ASSESSMENT OF PARENTS' COMPETENCES IN INFANT FLOATING

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Abstract

Many parents are keen to swim with infants, but they often misunderstand the nature of infant floating and are unable to do it properly. Some of parents lack the knowledge, skills and practical abilities to properly and appropriately handle the aquatic environment. The self-assessment of parental competence plays an important role in determining the weaknesses and strengths of various components of parent competences in infant swimming. Therefore, our study was aimed at studying and analyzing the self-assessment of parents' competences in infant floating. Based on the research results it would be possible to develop a more accurate model for the enhancement of the parents' competences required for infant floating and put forward recommendations for improving parents' competences. A self-assessment of the parents' competences in infant floating was conducted from the beginning of September 2017 until the end of October. 112 parents' participated voluntarily in the self-assessment of parents' competences in infant floating. The results of the self-assessment of parents' indicate that all of the components proposed by the scientists that influence parents' competences in infant floating play an important role. It could also be surely concluded that at present, the overall level of parents' competence in infant floating in the opinion of parents' is middling or some components of competence is little above middling. In general, all the parents' are of the opinion that parents should definitely supplement or acquire additional knowledge, skills and abilities in order to increase their level of competences in infant floating in order to be able to effectively apply their competences during independent lessons with their infants.

Keywords: *parents' competences, self-assessment in infant floating.*

Introduction

The beneficial effects of water on the human body have been known since ancient times. No other physical activity can be compared to lessons in the aquatic environment, since weightlessness and the horizontal position of the body help to relieve the spine. Frequent movements in such a position help the spine to feel a completely different load than in a vertical position in which human spends 2/3 of his life and it relieves the back and the tension between nerve endings (Barczyk, Skolimowski & Zawadzka, 2005). In addition, all regular swimming lessons have a multifaceted effect on human physical development, CNS and respiratory systems, helping to improve one's stance. Slow and rhythmic movements in the water improve blood supply and metabolism, strengthen the blood vessel system (Ahrendt, 1997; Sigmundsson & Hopkins, 2009).

Nowadays activities where children and parents participate together are becoming increasingly popular. It is a good opportunity to be together, socialize and enjoy the health benefits. (Francoise, 2014). One cannot always find the time, place, and the desire to do it. Therefore, the child's age could be highlighted here, as infants cannot handle themselves independently without parental assistance and presence (Meredith, Hicks, & Stephens, 2001). There are a variety of physical activities but in this article we pay particular attention to swimming.

The water environment is not alien to infants, since they had already been spent about nine months in such an environment. (Johnson, 1996). And if there is an opportunity to attend classes with an infant in the pool, parents often use it. It is also important to emphasize not only the well-being, but also the therapeutic benefits, since classroom activities are conducted under the guidance of a physiotherapist. It is very important how parents feel during these lessons and how they are able to complete the exercises with the infant independently and orient themselves in such a specific aquatic environment. (Ahrendt, 2002; Zhao et al, 2005; Федулова, 2011). Many parents are keen to swim with infants, but they often misunderstand the nature of infant floating and are unable to do it properly. They lack the knowledge, skills and practical abilities to properly and appropriately handle the aquatic environment. (Stallman, 2014).

The concept of competence has many different explanations, but in general we can relate it to abilities who based on knowledge, choose the most appropriate means for the given situation, act properly and act appropriately in concrete situation (Koķe, 2003).

It is important to help parents learn the proper infant swimming techniques so that they can apply it independently in the future during the child's development with a sense of security and conviction (Meredith, Hicks, & Stephens, 2001; Jovanovich, 2002). The self-assessment of parental competence plays an important role in determining the weaknesses and strengths of various components of parent competences in infant swimming (Stallman, 2014). Therefore, our study was aimed at studying and analysing the self-assessment of parents' competences in infant floating.

During the study, there was a theoretical possibility that the self-assesment structured based on the notions and opinions of different scientists and authors regarding competence in infant floating could produce significantly differing assessments in terms them of parents' self-assessment. Based on the research results it would be possible to develop a more accurate model for the enhancement of the parents' competences required for infant floating and put forward recommendations for improving parents' competences.

Material and methods

A self-assessment of the parents' competences level in infant floating was conducted from the beginning of September 2017 until the end of October and was organised at various branches of Riga Health Centre: RHC Kengarags, Imanta, Bolderaja and Ilguciema branch. 112 parents participated voluntarily in the self-assessment. It was found that 5 self-assessments from parents were invalid as they did not follow the proper instructions. As a result, 107 self-assessments from parents' were finally processed and analysed. The parents were on average 30.8±0.5 years old. 91.8% of the parents were women and 8.2% were men. The self-assessment on parents' competences was published on the Internet where each parent could voluntarily complete and submit the self-assessment online at a convenient for them time.

In order to enable the objective self-assessment of Parents' responses to the self-assessment and process the statistics mathematically, each item has five variants of responses expressed on a five-point scale (Raščevska, 2004; Kroplijs & Raščevska, 2010). The arithmetic mean for each item was determined by gathering the responses given on a five-point scale and carrying out a statistical analysis. The mean, standard deviation and mode was used to process the numerical data gathered from the responses.

Table 1

Self-assessment statement content of theoretical argument about parents' competence in infant floating

AUTHORS	COMPETENCE IN INFANT FLOATING					
	Knowledge of infant floating classes content and its understanding	Knowledge of the significance infant floating and their impact of infants' heath	Knowledge of infant floating	Skills in infant floating	Practical abilities in infant floating	Observance of safety in infant floating
Johnson, 1996	X	X	X			
Ahrendt, 1997		X				
Meredith et al, 2001	X		X	X	X	
Ahrendt, 2002	X	X	X	X	X	X
Jovanovich, 2002	X		X			X
Zhao et al, 2005	X	X	X			
Sigmundsson, & Hopkins 2009	X	X	X			
Федулова, 2011	X	X	X	X	X	X
Francoise, 2014	X	X		X		X
Stallman, 2014				X		X
Items of self-assessment	4, 5, 6, 8, 12, 13	4, 7, 16, 23, 27	8, 9, 14, 15, 24, 28	10, 17, 18, 19, 25, 29	11, 20, 21, 26	22, 23, 24, 25, 26,30

The choice of the items posed, and the design of the self-assessment was based on the works, opinions and methodological concepts worked out by various scientist and authors. The scientific concepts have been summarized and illustrated in the form of a table (refer Table 1),

- Knowledge of infant floating class's content and its understanding (Johnson, 1996; Meredith, Hicks, & Stephens, 2001; Ahrendt, 2002; Jovanovich, 2002; Zhao et al, 2005; Sigmundsson & Hopkins, 2009; Федулова, 2011; Francoise, 2014).
- Knowledge of the significance infant floating and their impact of infants' heath (Johnson, 1996; Ahrendt, 1997, 2002; Zhao et al, 2005 Sigmundsson & Hopkins, 2009; Федулова, 2011; Francoise, 2014).

- Knowledge of infant floating (Johnson, 1996; Meredith, Hicks, & Stephens, 2001; Ahrendt, 2002; Jovanovich, 2002; Zhao et al, 2005; Sigmundsson & Hopkins, 2009; Федулова, 2011).
- Skills in infant floating (Meredith, Hicks, & Stephens, 2001; Ahrendt, 2002; Федулова, 2011; Francoise, 2014; Stallman, 2014).
- Practical abilities in infant floating (Meredith, Hicks, & Stephens, 2001; Ahrendt, 2002; Федулова, 2011).
- Observance of safety in infant floating (Ahrendt, 2002; Jovanovich, 2002; Федулова, 2011; Francoise, 2014; Stallman, 2014).

Results

Components and their significance that impact the competences of parents' in infant floating and their self-assessment we can see in figure 1 and table 2.

The self-assessment of importance of competence components according to the results were ranked on a scale of 5 points where 1 was unimportant, 2 – less important, 3 – more or less important, 4 – rather important and 5 – very important (Figure 1, Table 2).

Table 2

Components and their significance that impact the competences of parents' in infant floating according to results of parents' self-assessment (n=107)

Components of competence		Mean arithmetical (points) ±standard deviation	Mode
Knowledge about	performance of the exercises	4.9±0.04	5
	use of equipment	4.1±0.1	4
	impact on the organism	4.9±0.03	5
	contraindications of floating	4.8±0.04	5
	observance of safety in water	5.0±0.01	5
	baby safety of to hold in water	4.9±0.03	5
	first aid	4.5±0.1	5
Skills and abilities	performance of the exercises in water	4.8±0.04	5
	to use of equipment and means	4.1±0.1	4
	performance of safe poses to hold in water	4.9±0.03	5

According to the parents' self-assessment. They should pay a great deal of attention to safety on the water while carrying out infant floating lessons independently on their own.

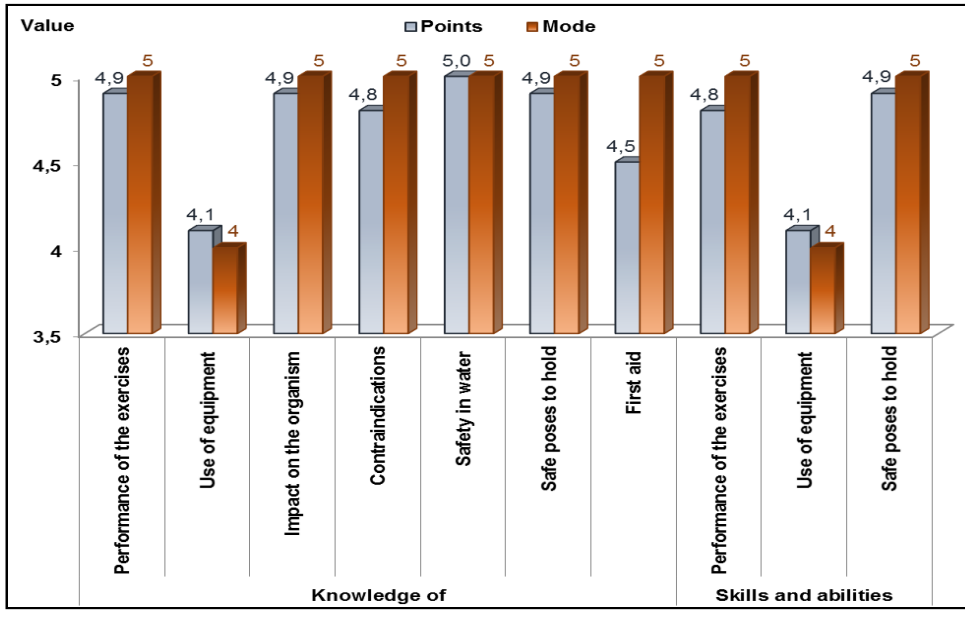

Figure 1. Components and their significance that impact the competences of parents' in infant floating (n=107)

The level of competence of parents in infant floating according to their own self-assessment can be seen in figure 2 and table 3.

Table 3

Level of parents' competences in infant floating according to results of parents' self-assessment (n=107)

Components of competence		Mean arithmetical (points) ±standard deviation	Mode
1.		2	3
Knowledge	the importance of parents' knowledge of infant floating that impacts their ability to independently perform exercises with infants	4.4±0.1	5
	overall knowledge of infant floating	2.8±0.1	3
	additional knowledge acquired by parents through gathering of information on the internet and literature on infant floating that describe the exercises and provide methodological instructions	3.1±0.1	3
	parents' theoretical knowledge of observance of safety in water	3.3±0.1	3
Skills	the importance of parents' overall skills in infant floating that impacts their ability to independently perform exercises with infants	4.4±0.1	5
	parents' skills in using those independently during infant floating lessons in the presence of an expert	4.5±0.1	5
	parents' skills in using those independently during infant floating lessons in the presence without expert	3.4±0.1	3
	parents' skills in following safety procedures in water while independently carrying out lessons in infant floating	4.1±0.1	4

Table 3 (Continued)

1		2	3
Practical abilities	the importance of parents' overall practical abilities in infant floating that impacts their ability to independently perform exercises with infants	4.3±0.1	5
	parents' practical abilities in using those independently during infant floating lessons in the presence of an expert	4.2±0.1	4
	parents' practical abilities in using those independently during infant floating lessons in the presence without expert	3.2±0.1	3
	parents' practical abilities in following safety procedures in water while independently carrying out lessons in infant floating	4.0±0.1	4

Level of competence of parents in infant floating according to the self-assessment results were ranked on a scale of 5 points where 1 was low, 2 – under middling, 3 – middling, 4 – above middling 5 – good (Figure 2, Table 3).

Many parents have marked their level of knowledge as "middling" during the self-assessment. This middling level of knowledge, skills and practical abilities as well can significantly affect them in carrying out infant floating lessons independently.

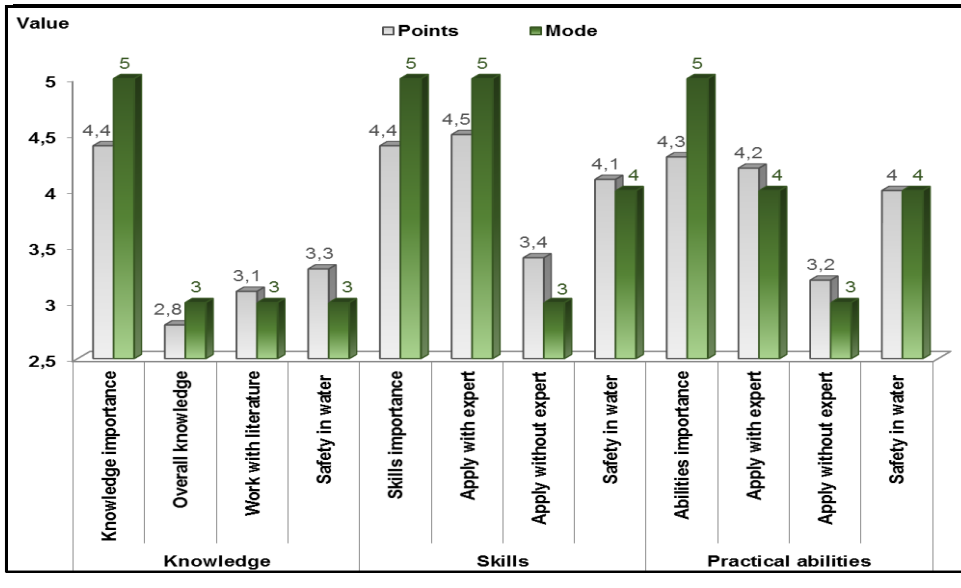

Figure 2. Level of parents' competences in infant floating according to mean results of parents' self-assessment (n=107)

Components to be additionally acquired or enhanced in order to improve the level of parents' competences in infant floating according to the results of parents' self-assessment can be seen in figure 3 and table 4.

Table 4

Competences components of infant floating in order to improve the level of parents' competences in infant floating according to results of parents' self-assessment (n=107)

Components of competence		Mean arithmetical (points) ±standard deviation	Mode
Knowledge	about performance of the exercises	4.9±0.04	5
	about use of equipment	4.0±0.1	4
	about impact on the organism	4.8±0.05	5
	about contraindications of floating	4.9±0.05	5
	about observance of safety in water	4.9±0.03	5
Abilities	to performance of the exercises in water	4.6±0.1	5
	to use of equipment and means	3.8±0.1	4
	to performance of safe poses to hold in water	4.6±0.1	5
Skills	to performance of the exercises in water	4.5±0.1	5
	to use of equipment and means in infant floating	3.7±0.1	4
	to performance of safe poses to hold in water	4.6±0.1	5

Analysing the self-assessment results the components that need to be enhanced for improving the parents' competences have been ranked on a scale of 5 points where 1 was no, 2 – rather no, 3 – minimum, 4 – rather yes and 5 – yes (refer figure 3 and table 4).

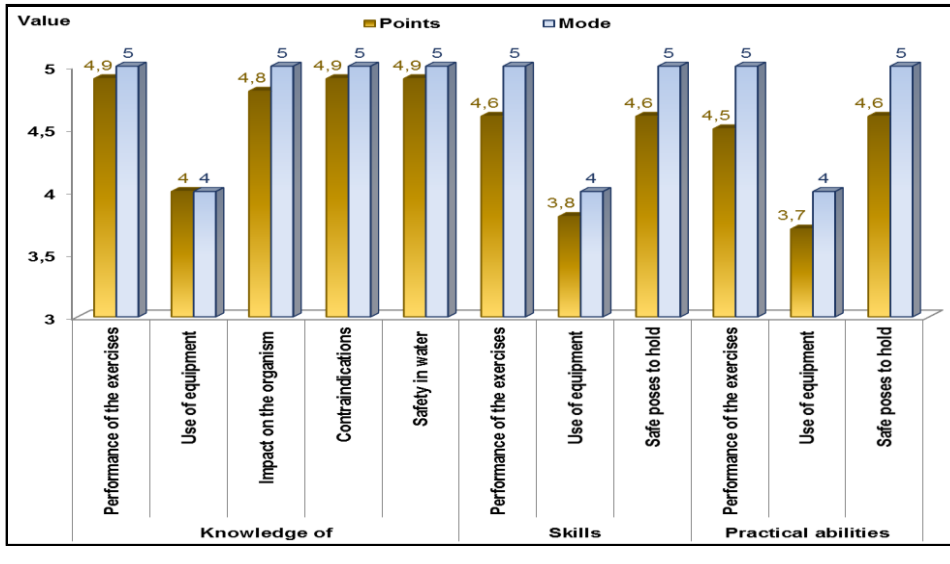

Figure 3. Competences components of infant floating in order to improve the level of parents' competences in infant floating (n=107)

Parents have responded positively during the self-assessment regarding enhancing their knowledge and therefore feel that they should definitely supplement their theoretical knowledge. Parents also believe that attending

lessons with specialists would help them further apply the knowledge acquired and information received in further practice during their lessons with infants independently. Parents believe that the more lessons they attend with professionals. The better they enhance their practical skills in infant floating.

Discussion

Analysing the self-assessment of significance of competence components according to the parents' self-assessment it can be seen that the only difference in the self-assessment are components related to the use of additional equipment and accessories as in all cases in terms of knowledge. Skills as well as practical abilities parents have rated this component as "rather important" and not "very important" Very important self-assessment was given to the components related to safety procedures and holding the infant safely in the water. It means that practically all the 107 respondents indicated that it is an important component that significantly affects the parents' competence in infant floating. The authors (Ahrendt. 2002; Zhao et al. 2005; Федулова. 2011) also emphasize in their literature that it is very important for parents to orientate themselves in a specific water environment and to be safe when they are in the water with infant.

All other components range between 4.5 and 4.9 points. That can on the whole be interpreted as very important and their self-assessment "rather important" and "very important" is very close to the maximum self-assessment (refer figure 1 and table 2).

Reviewing the mode values of significance of competence components, was found that the results are quite similar to the arithmetic mean. According to the modes it could be concluded that the component related to the use of additional equipment and accessories (knowledge. skills and abilities) is 4. It indicates that the most common response was "rather important". On the other hand, modes for all the other components were 5 which mean that the most common self-assessment was "very important" (refer figure 1 and table 2).

Analysing the level of competence of parents in infant floating according to their own self-assessment it can be seen that the significance of the competences (significance of knowledge, skills and practical abilities) that is necessary for parents have been rated as more than the "above middling" – 4 points i.e. knowledge. Skills and practical abilities have been rated from 4.3 to 4.4 points. The self-assessment of parents overall theoretical knowledge of infant floating was the lowest. The arithmetic mean was 2.8 points, which is between "under middling" and "middling". Among knowledge of components additional knowledge acquired by

parents through independent gathering of information on the Internet and literature on infant floating (3.1 points), as well as theoretical knowledge of observance of safety procedures in water (3.3 points), were also assessed just a bit above the self-assessment "middling". A similar self-assessment can be seen also for skills and practical abilities related to independently using skills and practical abilities during infant floating lessons in the absence of an expert – 3.4 points and 3.2 points. self-assessment of skills and practical abilities of components related to following safety procedures in water while independently carrying out lessons in infant floating was also relatively similar – skills 4.1 points and practical abilities 4.0 points. On the other hand respondents assessed the usage of skills and practical abilities independently during infant floating lessons in the presence of an expert a lot higher than the other competences. Parents evaluated the usage of skills in the presence of an expert as 4.5 and the usage of practical abilities as 4.2. It meant that the arithmetic mean of the parents' self-assessment was between "above middling" and "good" (refer figure 2 and table 3). Similarly, authors (Meredith, Hicks, & Stephens, 2001; Jovanovich, 2002) write that it is important to help parents learn the correct new-born swimming skills in these common activities with infant swimming specialists.

Analysing the mode results of parents' self-assessment of competences one can observe a picture similar to that of the results of the arithmetic mean. The lowest mode value – 3 was for the component related to overall knowledge of parents of infant floating, additional knowledge acquired by parents through independent gathering of information on the Internet and literature, theoretical knowledge of observance of safety procedures in water and skills and practical abilities related to working independently during infant floating lessons in the absence of an expert. It could be concluded from the mode values that the most common response value was "middling". Parents' self-assessment of skills and practical abilities of components related to observance of safety procedures in water as well as use of practical abilities independently during infant floating lessons in the presence of an expert were rated as 4 which indicates that the most common response of this component was "above middling". On the other hand, usage of skills independently during infant floating lessons in the presence of an expert has been rated in the parents' self-assessment with a mode 5. This means that the most common response in the parents' self-assessment was "good". The overall opinion of parents regarding significance of overall knowledge, skills and practical abilities in infant floating that impacts their ability to independently perform exercises with infants was assessed with a mode of 5 which once again emphasises the

very high importance of the level of this competence (refer figure 2 and table 3). Analysing the results of the parents' self-assessment of components to be additionally acquired or enhanced in order to improve the level of parents' competences in infant floating it can be seen that the self-assessment of enhancement of the competence related to the use of equipment and accessories ranges between 3.7 to 4.0 points according to the arithmetic mean i.e. "rather yes". All the other competence components in the parents' opinion were rated from 4.5 to 4.9 points which in accordance with the self-assessment scale is between "rather yes" and "yes". On the other hand, parents would be willing to additionally acquire and enhance their knowledge of such competence components such as knowledge of performance of exercises, of contraindications of swimming and of observance of safety procedures in water. The arithmetic mean of the responses is 4.9 points which is maximally close to "yes we need to additionally acquire or enhance" (refer figure 3 and table 4).

Analysing the mode values of components to be additionally acquired or enhanced in order to improve the level of parents' competences in infant floating it can be seen that the most common response of parents for knowledge, skills and practical use of equipment and accessories is "rather yes" with a value of 4. In turn the majority of parents have expressed a "yes" to additionally acquire or enhance all the other components to improve their competences in infant floating. This is affirmed by the mode value of 5 highlighting the necessity for their enhancement (refer figure 3 and table 4).

Conclusions

Having analysed the results of the research, we can draw conclusions about the importance and level of parents' competence in infant floating.

The results of the self-assessment of parents indicate that all of the components proposed by the scientists and authors that influence parents' competences in infant floating play an important role. It could also be surely concluded that at present, the overall level of parents' competence in infant floating in the opinion of parents' is middling or some components of competence is little above middling. In general, all the parents are of the opinion that parents should definitely supplement or acquire additional knowledge, skills and abilities in order to increase their level of competences in infant floating in order to be able to effectively apply their competences during independent lessons with their infants.

According to the results of the research we can conclude that in order to increase the level of parents' competence in the infant floating, it is necessary to pay attention to the acquisition or improvement of the

following main components: Knowledge about performance of the exercises,about impact on the organism, about contraindications of floating, about observance of safety in water, skills and abilities to performance of the exercises in water, to performance of safe poses to hold in water.

Based on the research results it would be possible to develop a more accurate model for the enhancement of the parents' competences required for infant floating and put forward recommendations for improving parents' competences.

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ORIGINAL RESEARCH PAPER

HOW OBJECTIVELY MEASURED PHYSICAL ACTIVITY IS RELATED TO PSYCHOLOGICAL CONSTRUCTS: A PILOT STUDY AMONG ESTONIAN STUDENTS

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Abstract

The aim of this study was to explore the relationships between objectively measured physical activity and intrinsic motivation and the components of theory of planned behavior. Participants were 64 school students at age of 13 – 14 years from seven and eight grades in Estonia. An accelerometer was used to measure the moderate-to-vigorous physical activity twice during seven days with the interval of four weeks. In the first time of data collection, the intrinsic motivation, perceived behavioural control, attitudes, subjective norms, and intention toward physical activity in a leisure-time were measured. The path model was used to examine the relationships among the study variables. The model, in which the psychological constructs measured at the beginning of the study were entered to predict moderate-to-vigorous physical activity measured four week later, exhibited adequate fit to the data: $\chi^2 = 5.77$, $df = 5$; CFI = .985; RMSEA = .050. The path from intention to predict moderate-to-vigorous physical activity was significant ($\beta = .24$, $p < .01$). The model explained 6% of the variance in moderate-to-vigorous physical activity. By adding moderate-to-vigorous physical activity measured first time into the model increased the variance to be explained to 17%. Goodness of fit indices were also on acceptable level. The results confirmed that the components of the theory of planned behavior are indirectly and directly related also to objectively measure physical activity. The previous experience of physical

activity in leisure time e.g. past behavior must be considered for promotion the physical activity among adolescents.

***Key Words**:* Moderate-to-vigorous physical activity, intrinsic motivation, Theory of planned behavior.

Instruction

Physical activity (PA) has health benefits in children and adolescents. PA has positive effects on reducing overweight and obesity, cardiovascular diseases, cancer, osteoporosis, and depression (Janssen & LeBlanc, 2010). Despite this, data from more than 100 countries showed a prevalence of 80.3% of physical inactivity among adolescents (Hallal et al., 2012). There are a lot of research evidence based on self-determination theory (SDT; Deci &Ryan, 1985) and theory of planned behavior (TPB; Ajzen, 1991) showing how psychological variables are associated with PA. The links between psychological variables and PA were extensively established through self-reported recall questionnaire (see for review, Hagger & Chatzisarantis, 2015).

Most of the methods used in these studies are self-reported surveys. However, this method may be inaccurate due to unreliable memory recall, and it could be affected by social desirability (Adams et al., 2005). Compared with non-self-report measures (or "objective measures"), researchers showed that scores derived from self-report measures generally lacked reliability and validity (Prince et al., 2008). Therefore, the use of objective measures (e.g. pedometers, heart rate monitors, accelerometers) to assess PA and sedentary behaviours has become commonplace in recent studies. Several researchers (Dishman, Mciver, Dowda, Saunders, Pate, 2015; Wang, 2017) using SDT have found that autonomous motivation predicted positively objectively measured PA. Identified and intrinsic measures of autonomous motivation were the strongest predictors of PA (Dishman et al., 2015). An amount of the variance accounted by a single measure of relative autonomous motivation (RAI) for PA was modest (i.e., 3.5%; Wang, 2017).

The TPB posits that an individual's intention which represents also one's motivation and sense of a conscious decision to preform behaviour is directly influenced by three antecedents: attitudes, subjective norms, and perceived behavioural control (Ajzen, 1991; Hagger, Chatzisarantis, & Biddle, 2002). Researchers using the self-reported method have consistently showed the strong effect of attitude and perceived behavioural control on intention and on consequent behaviour including PA (Hagger et al., 2009; Hagger & Chatzisarantis, 2015). However, few studies have made an attempt to explore the relationships between the components of TPB and

objectively measured PA. The role of intention and attitude for prediction an objectively measured PA hase been established in obese adults and children with and without certain coordination disorders (Chevance et al., 2018; Kwan, Cairney, Hay, & Faught, 2013). The authors found that attitudes and subjective norms partially mediated the relationship between PA and motor impairment /coordination disorders.

In the present study we formulated three hypotheses. At first, we hypothesized that intrinsic motivation toward PA in leisure time will have an effect on the proximal determinants of intention and actual behaviour (objectively measured PA) from the TPB as hypothesized in the trans-contextual model (Hagger, et al., 2009). Secondly, we assumed that past PA behaviour has an increasing effect on actual PA behaviour four weeks later. Thirdly, the effects of the proposed model were assumed to hold regardless of the effect of past PA behaviour.

Material and methods

Participants and procedures

Participants were 64 school students (17 boys and 47 girls) at age of 13-14 years from seven and eight grades in Estonia. The schools draw their students from an area characterized as 'middle-class' and matched the distribution of socioeconomic status levels. Students were taking physical education as a required course (two times a week, 45 – 50min per lesson). Consent for school pupils' participation in the study was obtained from parents and the school principals prior to data collection. Students were informed that they would be asked to complete a short questionnaire. They were told that participation was voluntary and they could choose to opt out if they desired. Students completed the questionnaires in gym within twenty minutes during the big break time.

In the first wave of data collection, the leisure-time moderate-to vigorous physical activity (LT1 MVPA) during the seven days was recorded and the PBC, attitudes, subjective norms, self-identity and intention components from the TPB and motivation in a leisure-time PA context were measured. Four weeks later, LT2 MVPA behavior was assessed. A four-week interest period was employed, because it represents a long-range prediction of behavior relative to the comparatively short-range effects previously studied using the TPB (Hagger et al., 2002).

Measures

Physical activity was measured using the Actigraph GT3X (ActiGraph LLC, Pensacola, FL). Each child wore an accelerometer on their waist during waking hours at least 10 hours for seven consecutive days except swimming and bathing activity. The data files were downloaded

using ActiLife software 6.13.3. The sampling interval (epoch) was set at 15 s. Accelerometer data were considered valid if over 600 min (10 hours) of recorded data per day at least four days out of seven were present. Zero counts of consecutive 60 min were classified as non-wear time. The PA intensity level in accelerometers was measured using Evenson, Catellier, Gill, Ondrak, & McMurray, (2008) cutoff points. The data of LT MVPA was evaluated as a percentage from the total recorded PA. The study was in accordance with the Declaration of Helsinki and approved by Research Ethics Committee of the University of Tartu (nr 268/M-6).

The theory of planned behaviour. Attitude, perceived behavioural control (PBC), subjective norms and intention subscales from the TPB questionnaire were used. Three items drawn from Courneya and McAuley (1994) were used to measure behavioural intentions (e.g., 'I intend to do active sports and/or vigorous physical activities in the next four weeks...') on seven-point Likert-type scales anchored by 'strongly disagree' (1) to 'strongly agree' (7). Attitudes were assessed in response to the following statement: 'Participating in active sports and/or vigorous physical activities during my leisure time in the next four weeks is...' Responses were measured on four seven-point semantic differential items with the following end points: bad-good, harmful-beneficial, unenjoyable-enjoyable. PBC was assessed through three items (e.g. 'I feel in complete control over whether I do active sports and/or vigorous physical activities in my leisure time in the next five weeks') measured on seven-point Likert-type scales ranging from 'no control' (1) to 'complete control' (7). Subjective norms were assessed by three items (e.g., 'People important to me think that I should do active sports and/ or vigorous physical activities during my leisure time in the next four weeks') on seven-point scales with 1 ('strongly disagree') to 7 ('strongly agree') endpoints.

Intrinsic motivation in a leisure-time PA context was assessed through the four-item intrinsic motivation subscale from the Behavioral Regulation in Exercise Questionnaire BREQ-2 **(**Markland, & Tobin 2004). An example item included: "I exercise because it is fun". Responses to each item were measured on seven point scales ranging from "very true" (7) to "not true at all" (1).

The TPB and SDT based questionnaires used in this study have been previously validated in different cultural contexts including Estonian sample (Hagger et al., 2007, 2009).

Data analysis

Prior to data analysis, a reliability coefficient for the scales was assessed. The value of ≥.70 was considered acceptable (Nunnally & Bernsterin, 1994). The mean scores of the scales were calculated summing

up the responses of each items and divided by the number in the corresponding scale. Relationships between study variables were examined using path analysis. The adequacy of the path model was estimated with multiple goodness-of-fit indices: the comparative fit index (CFI), non-normed fit index (NNFI), and the root mean square error of approximation (RMSEA). Acceptable fit of the hypothesized model with the data is supported if values exceed .90 for the CFI, and NNFI, and are equal to or less than .08 for the RMSEA (Hu & Bentler, 1999).

Results

The reliability coefficients and descriptive statistics are presented in Table 1. All reliability coefficients exceeded the 0.70 criterion for acceptability (Nunnally & Bernsterin, 1994).

Table 1

Descriptive Statistics, internal consistency, and correlations between study variables

	1	2	3	4	5	6	α	M	SD
1.LT MVPA time 1								6.75	2.38
2.LT MVPA time 2	.38**							1.42	.70
3.Intrinsic motivation	.33*	.16					.93	5.63	1.62
4.Intention	.28*	.24	.48**				.82	5.75	1.12
5.Attitude	.12	.15	.60**	.52**			.83	6.25	.77
6.Perceived behavioural control	.07	.20	.37**	.63**	.61**		.86	5.99	.96
7.Subjective norm	.14	.10	.35**	.47**	.67**	.74**	.78	5.99	.95

Note. LT MVPA = leisure-time moderate-to-vigorous physical activity. M = mean value of the LT MVPA is expressed as a percentage of the total recorded time. *P <.05; ** P< .01.

The path model presented in Figure 1. shows that intrinsic motivation toward leisure time physical activity was significantly related to the determinants of intention. From the determinants, attitude and perceived behavioural control were positively and subjective norms negatively related to intention which in turn predicted significantly LT MVPA. This model explained 6% of the variance in LT2 MVPA. Goodness of fit indices were on acceptable level: $\chi^2 = 5.77$, df= 5; NNFI = .984; CFI = 985; RMSEA = .050.

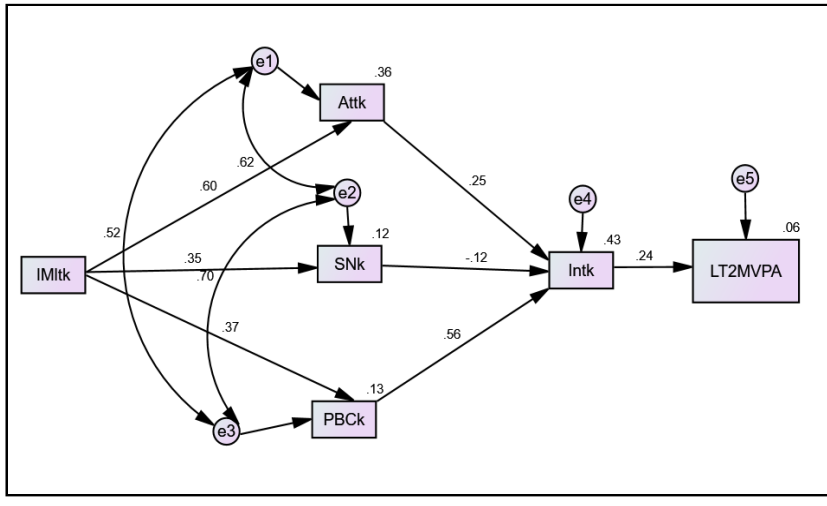

Figure 1. Path model predicting moderate-to-vigorous physical activity from intrinsic motivation and the components of theory of planned behaviour

Note. IMltk = mean value of the intrinsic motivation towards leisure-time physical activity; Attk = mean value of the attitude; SNk = mean value of the subjective norms; PBCk = mean value of the perceived behavioural control; Intk = mean value of the intention; and LT2MVPA = moderate-to-vigorous physical activity measured four weeks later; e1–e5 are error terms associated with each measured variable.

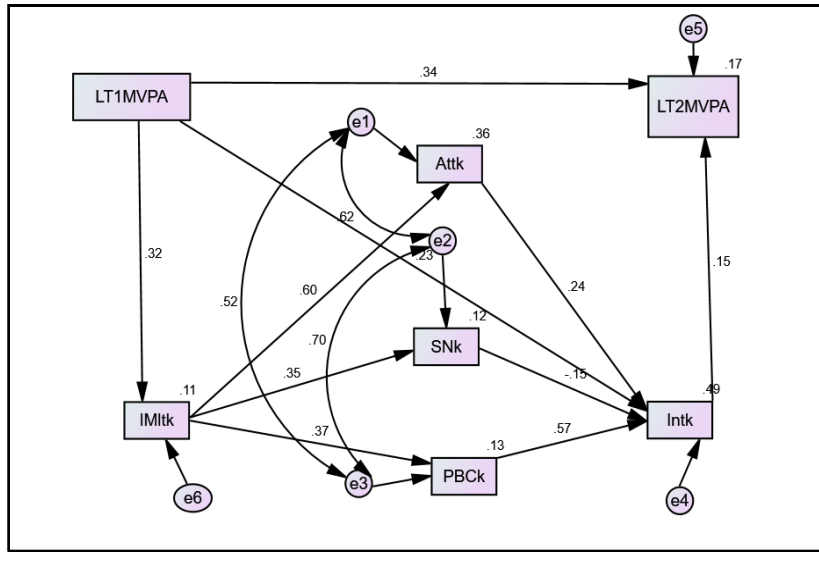

Figure 2. Path model predicting moderate-to-vigorous physical activity from the past experience of physical activity in leisure time, intrinsic motivation and the components of theory of planned behaviour

Note. IMltk = mean value of the intrinsic motivation towards leisure-time physical activity; Attk = mean value of the attitude; SNk = mean value of the subjective norms; PBCk = mean value of the perceived behavioural control; Intk = mean value of the intention; LT2MVPA = moderate-to-vigorous physical activity measured four weeks later and LT1MVPA = the past experience of moderate-to-vigorous physical activity; e1–e6 are error terms associated with each measured variable.

The inclusion of the past moderate-to-vigorous physical activity behaviour (LT1MVPA) into the model indicated that the relationships between intrinsic motivation and the determinants of intention and the latter with intention were hold, whereas the effect of intention on LT2MPVA turned out to be nonsignificant. Consequently, past behaviour attenuates the intention-behaviour relationship. In addition, the inclusion of past behaviour increased the explained variance in LT2MPVA from 6% to 17%. Goodness of fit indices were also on an acceptable level.

Discussion

The results of this study in generally confirm the findings of the research where the data were collected via self-reported measures (Hagger, et al., 2009; Hagger & Chatzisarantis, 2015). The first hypothesis that intrinsic motivation toward PA in leisure time has an effect on the proximal determinants of intention and objectively measured PA was confirmed. In both presented models with and without past PA behavior the negative relationship between subjective norm and intention was not significant. This is in line with the notion reported by several authors that subjective norms are not the most theoretically-relevant socially influential construct for understanding the behavior change (Courneya, Plotnikoff, Hotz & Birkett, 2000).

The model in which the past PA behaviour was included accounted for a greater amount of variance in PA than the model without the inclusion of the past PA behaviour. In total the model accounted for 17% of the variance in LT MVPA behaviour and supported the second hypothesis about an increasing effect of past behaviour. However, in several models of motivation for predicting self-reported PA (Hagger, et al., 2007, 2009; Hamilton & White, 2008), the total amount of the variance accounted for was higher than in the model, in which PA was objectively measured (Dishman et al., 2015; Kwan et al., 2013; Wang, 2017). It is noteworthy that the total amount of the variance in LT MVPA accounted for in the model presented in this study was higher than in above-mentioned studies.

The third hypothesis that the past LT MVPA will not attenuate the relationships between the components of the model was supported partially as the effect of intention on LT MVPA behaviour was no longer significant.
A unique contribution of this study is that an attempt was made to test the relationships between objectively measured PA and the psychological constructions from both, the self-determination theory and the theory of planned behaviour. The results of this study are important because identifying the determinants of objectively measured PA over time representing a crucial step in designing intervention programme in future.

These results should be interpreted with caution due to the sample size. The sample size was not large enough to segregate into meaningful groups for separate moderator analyses like gender or age.

Conclusions

The intrinsic motivation toward PA in leisure time was related to intention via attitude and perceived behavioural control, and intention predicted objectively measured PA.

Past moderate-to-vigorous physical activity increased objective physical activity four week later.

The relationships between components of the proposed model to predict objective physical activity were similar to those previously reported in the trans-contextual model, where the physical activity was measured by self-reported data.

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REVIEW PAPER

A SYSTEMATIC REVIEW: A COMPARISON OF TRADITIONAL WITH MOTOR LEARNING CORE STABILITY TRAINING APPROACHES REGARDING THE EFFECT ON LOWER AND UPPER EXTREMITIES USE, BALANCE AND FUNCTIONAL PERFORMANCE IN OLDER ADULTS

A comparison of traditional with motor learning core stability training approaches in seniors: A Systematic Review

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Abstract

Key points. *Exercise-based core stability training interventions demonstrate considerable emphasis on traditional types of strength training components and only few exercise programs consider motor learning components to enhance function in older adults. It remains unclear whether additional motor learning components are more beneficial for effecting core stability training related outcomes in comparison to traditional exercise programming. Exercise practitioners and therapists should be aware that structured exercise programs for core stability training can be flexible in design, however, come with the probability of impacting differently on core*

stability training related outcomes in older adults. ***Background.*** *To influence core stability related functioning in elderly, several types of resistance training interventions may be performed. Different types of core stability training will differently effect on training related outcomes. The objective of this systematic review is to investigate the effect of motor learning training strategies in comparison to traditional strength training for core stability.* ***Methods.*** *Selected articles were identified from MEDLINE, EMBASE, CINAHL, PsycINFO and Cochrane. Studies were included if published in English and aimed to train core stability. The studies should target subjects aged 60 years and older.* ***Results.*** *The search strategy yielded 13 studies that met the inclusion criteria; 11 describing traditional trunk strength exercising programmes and 2 using motor learning training strategies. The results do not allow favoring one training approach against the other due to insufficient studies comparing the two training approaches.* ***Conclusion.*** *Currently available literature does not present a wealth of information about the best strategy for core stability training in seniors. The limited availability of high-quality prospective studies that used a comparison between traditional and training approaches that use elements of motor learning warrants targeted future research investigating and comparing the effects of these approaches.*

Keywords: *Motor control exercise, core training, cognitive-trunk training, trunk control, resistance training, balance, videogames, exergames*

Introduction

About a third of community-dwelling people over 65 years of age fall each year (1, 2) and the rate of fall-related injuries increases with age (3). The aging process results in a number of functional changes that contribute to the increased fall incidence (4). Falling is a common geriatric syndrome affecting the general elderly population, but also older populations with cognitive impairment (5). Sarcopenia, or reduced muscle mass and function, is believed to be the first symptom of the cycle towards frailty (6) that may consequentially lead to impairments in ambulation; e.g. slowing of gait (7) and increased gait variability (8).

Gait has long been perceived primarily an automated process (9), and until recently gait related falls were mainly viewed as a failure of these motor mechanisms. Recent research based on dual-task paradigms converge on the notion that cognition, gait and the potential for falls are linked with each other in old age (10, 11). Training interventions aimed at improving gait show different effects on gait related outcomes based on the training type. Recent evidence supports the notion that timing and coordination

deficits related to mobility difficulties in older adults rather improve through task-oriented motor learning exercises, whereas standard exercise programs have no such effect (12). This might also explain some of the seemingly contradictory guidelines when it comes to improve gait and prevent falls in elderly. Where it seems important to include progressive resistance training when the training goal is to improve gait speed (13) the inclusion of this training component is deemed less crucial when the aim is to prevent falls (14).

A multi-component exercise intervention aiming to improve fall rates and gait ability in physically frail older adults should contain elements of both strength, endurance and balance exercise (15). While addressing muscle strength properties and training postural control are important components of training programs, there may be more potential to improve function of gait in older adults by targeting neurologic factors and integrating neuro-cognition in training programs (16, 17). Although evidence supports neuromuscular training for effective gait enhancement and fall prevention, many approaches primarily target biomechanical factors and do not explicitly consider cognitive or neurological components (18).
Core stability exercises are considered key components of training programs (19).Core stability is based on three subsystems: the passive spinal column, active spinal muscles and a neural control unit. Core stability is related to the body's ability to control the trunk in response to internal and external disturbances (20). There is evidence of a clear relationship between trunk muscle activity and lower extremity movement (21). Association between trunk muscle strength and functional performance also have been described (22), (23) To gain optimal core stability it is important being able to appropriately recruit muscles together with good timing of the muscle contractions (24) . Training invoked variations in the efficiency with which motor actions can be generated influence the stability of coordination (25) and different types of core muscle training effect differently on physical functioning (26, 27); e.g. on gait function in elderly individuals (28). The importance of voluntary control over the trunk muscles has more recently been emphasised (29) and trunk posture adaptation precedes decline in gait speed (30). To be able to produce appropriate muscle responses while moving, three levels of motor control should be combined: first, the spinal reflex level, second, the brain stem level pathway that coordinates vestibular and visual input and third, the level of cognitive programming that is based on stored central commands leading to voluntary adjustments (31).

So far no consensus has been reached among exercise and conditioning specialists regarding what core exercises are most effective influencing the control of spine equilibrium and mechanical stability for

improved walking. Whether the recently reviewed core strength training programs (4) for example included motor learning principles (where in addition to trunk region activity supraspinal centers are also constantly in increased activity(28)) and are, because of this, differing in their effectiveness when compared to more traditional core stability training (where superficial trunk muscles or deep trunk muscles, such as transversus abdominis and multifidus, or both are activated (57)) is unclear. There is evidence of core muscle training, that favoured exercises implementing motor learning principles against general exercise because of superior pain and disability outcomes characterising functional activities in low back patients (59), however substantiated consensus of it cannot be reached We hypothesized that programs applying motor learning theory to core stability training programs improve lower and upper extremities use, balance and functional performance in older adults more compared to traditional types of core strength training. Thus, the purpose of this study was to systematically review the literature with the aims (a) to report on motor skill training in core stability exercise programs and (b) to contrast the effects of more traditional training programs with motor skill training programs on lower and upper extremities use, balance and functional performance in older adults. The following PICO (P: patient, problem or population; I: intervention; C: comparison, control or comparator; O: outcome) research question (32) guided through this systematic review: "What is the effect of motor learning training strategies compared to traditional strength training for Core Stability on lower and upper extremities use, balance and functional performance in older adults?"

Material and methods

Data sources and searches.

Core stability, defined as "activation of deep trunk muscles that stabilise lumbar spine and pelvis (33, 34)" is associated with more efficient use of the lower and upper extremities and improved balance/functional performance outcomes in older adults (4). Based on this definition and these outcomes a search strategy was developed in collaboration with a librarian from the Medical Library of the University of Zurich. The search period covered all years from the inception to August 2017, and included EMBASE, MEDLINE, Cochrane (PubMed), CINAHL, and PsycINFO. Searches were undertaken using MeSH headings and text words adapted to the different databases. Example of the specific search strategy is seen in Table 1. The bibliographies of all eligible articles and related reviews, as well as recent conference proceedings, were checked through hand searching. To ensure the clarity and transparency of reporting, the PRISMA guidelines (35) were followed.

Table 1

The specific search strategy done in the EBSCOhost database

#	Query	Limiters/Expanders	Last Run Via	Results
1	**2**	**3**	**4**	**5**
S4	S1 AND S2 AND S3	Search modes - Find all my search terms	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL with Full Text	190
S3	((MH "Exercise") OR (MH "Therapeutic Exercise") OR (MH "Balance Training, Physical") OR ((MH "Balance, Postural") AND (therap* or training* OR exercise*))) OR (TX (exercise OR physical N3 therapy OR physiotherapy OR pilates OR (((muscle N3 strength) OR resistance OR balance) N3 (training OR therapy))))	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL with Full Text	307,481
S2	TI (((motor N3 control) OR (neuromuscular N3 control) OR (motor N3 skill) OR (cognit* N3 motor) OR (cognitive N3 trunk) OR feedback OR (swiss N3 ball)) N6 (training OR exercise* OR therapy OR rehabilitation OR mov*)) OR TI ((cognit* OR propriocept* OR coordinative OR voluntary OR deliberat* OR intentional* OR willful OR wilful OR purpose* OR designed OR planned OR intended) N6 (training OR exercise* OR therapy OR rehabilitation OR mov*)) OR TI (sensorimotor OR sensorymotor OR (sensory N3 motor) OR videogames OR exergames OR "dual task" OR proprioreception OR (coordinat* N3 muscle*)) OR AB (((motor N3 control) OR (neuromuscular N3 control) OR (motor N3 skill) OR (cognit* N3 motor) OR (cognitive N3 trunk) OR feedback OR (swiss N3 ball)) N6 (training OR exercise* OR therapy OR rehabilitation OR mov*)) OR AB ((cognit* OR propriocept* OR coordinative OR voluntary OR deliberat* OR intentional* OR willful OR wilful OR purpose* OR designed OR planned OR intended) N6 (training OR exercise* OR therapy OR rehabilitation OR mov*)) OR AB (sensorimotor OR sensorymotor OR (sensory N3 motor) OR videogames OR exergames OR "dual task" OR proprioreception OR (coordinat* N3 muscle*))	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL with Full Text	19,891

Table 1 (Continued)

1	2	3	4	5
S1	(((MH "Torso") OR (MH "Thorax+") OR (MH "Pelvis") OR (MH "Back") OR (MH "Abdomen+") OR TX (torso OR trunk OR back OR abdomen OR pelvis OR thorax)) AND TX (muscle N3 strength OR ((muscle N3 composition) AND (balance OR ‘‘functional performance’’ OR (falls AND (association OR relationship OR correlation))))) OR TX (trunk OR core OR postural) N3 (strenght* OR stabili*)) AND ((MH "Aged+") OR TX ((aged OR elder*) N3 (person* OR patient* OR man OR men OR woman OR women OR people)))	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL with Full Text	3,007

Selection criteria.

The search strategy included: 1) all types of physical exercise training for the core stability, including studies that focused on cognitive motor programming, 2) randomized control trials (RCT), controlled clinical trials (CCT) or one-group pre-post intervention studies, 3) individuals with a mean age of 60 years or older. Study outcomes were determined on efficiency of using the lower and upper extremities and improved balance/functional performance outcomes in older adults, which included measures of muscle strength, balance, functional performance and/or fall-related outcomes. Studies were excluded if published as an abstract without full text publication, designed as a single case study or written in languages other than English.

Selection process.

The first step was the removal of duplicate citations. Thereafter two reviewers (RK, AL) determined which studies were to be included by independently screening of title, abstract and keywords. The a priori set inclusion and exclusion criteria were applied to the articles (An article was eligible, if the investigator examined traditional (TRAD) or motor learning (ML) training targeting trunk/core stability in humans. Only studies were included that carried out an intervention (irrespective of the intervention duration). Subsequently, the results from the screening were discussed to reach consensus regarding the inclusion decisions. In case of disagreement, EDB served as referee. Full text reading of the remaining literature yielded the final list of papers.

Data extraction and data synthesis.

A purpose adjusted individualized data extraction form (36) was used to collect data from single studies. The extraction of the data included (1) reference information: author and date; (2) characteristics of study population: number of participants, sex, age; (3) characteristics of physical

exercise intervention: type of exercise, frequency, intensity and duration; (4) characteristics of outcomes: outcome measures and results. The data are presented in the results section as a descriptive summary of the studies and their results. Furthermore, a qualitative synthesis of the studies was executed. A meta-analysis was not performed due to the heterogeneity of intervention types and outcome variables among the limited amount of two studies identified using a ML approach for training. No substantial missing data was detected; therefore, there was no need to contact authors of the selected studies. Effect sizes from studies not reporting these were calculated using the following equations: Cohen's d = (M2 – M1) ⁄ SD pooled; where M is the mean of group 1 or 2 and SD is standard deviation, and Cohen's f = sqrt (eta2/(1-eta2)); where sqrt means square root and eta2 is η^2 (37). Cohen's d effect sizes of 0.20, 0.50, and 0.8 are termed *small*, *medium*, and *large*, respectively, whereas Cohen's f effect sizes of 0.02, 0.15, and 0.35 are termed *small*, *medium*, and *large*, respectively (37).

Quality appraisal.

Quality evaluation of the studies was done by reporting potential sources of bias (38). For critical quality appraisal, the purpose-adjusted Downs & Black checklist for randomized and non-randomized studies of health care interventions was used (39). The quality checklist consisted of 27 items having a theoretical maximum score of 28 points. The checklist scored 5 different domains: the quality of reporting (10 items, maximum 11 points), the external validity (3 items, maximum 3 points), internal validity – bias (7 items, maximum 7 points), internal validity – confounding (selection bias) (6 items, maximum 6 points) and power (1 item with maximum 1 point). The scoring of the last item (''study power'') was modified from a 0 – 5 scale to a 0 – 1 scale, where 1 was scored if the authors reported whether and how they determined their sample size a priori. For intervention studies with a one-group design several items had to be scored 0 (items 5, 14, 15, and 21 – 25), which implied a possible range score from 0 to 19 for those study designs. A summary of the set criteria for quality assessments that were used is displayed in Table 3. The quality evaluation procedure was done independently by two reviewers (AL, RK), as previously described (38). The level of agreement was assessed with Cohen's kappa analysis on all items of the checklist. Landis and Koch's benchmark for assessing agreement ranges from almost perfect (0.81 – 1.0), substantial (0.61 – 0.8), moderate (0.41 – 0.6), fair (0.21 – 0.4), slight (0.0-0.2), and poor (<0) (40). Disagreements were resolved by consensus or by consulting a third reviewer (EDdB).

Results

The database search returned 398 results. Eight additional potentially eligible articles were retrieved from hand searching. The total amount reduced to 310 after duplicates were removed. 287 articles were excluded after reviewing the titles and abstracts for eligibility. Full versions were retrieved for 23 articles, of which 13 were eligible for inclusion. The article screening process is detailed in Figure 1.

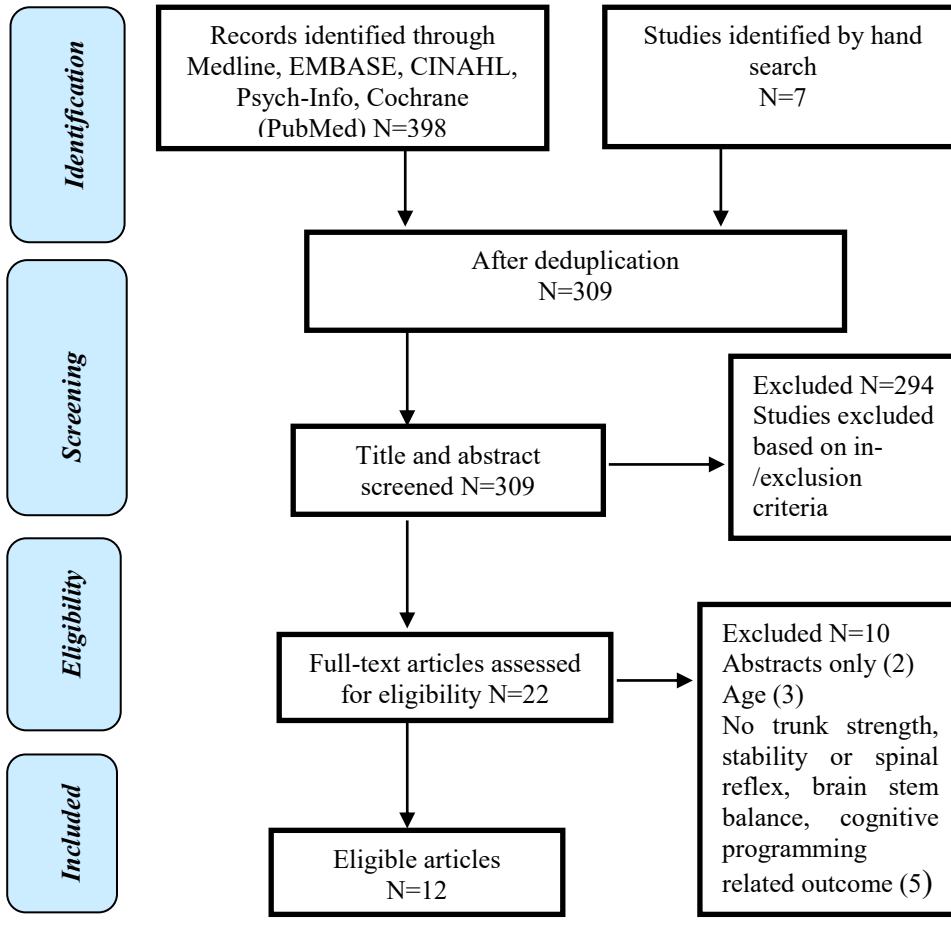

Figure 1. Study selection flow diagram

Description of included studies

Study details and intervention summaries are displayed in Table 2. Four studies were conducted in the United States, three in Germany, two in Australia, two in South Korea, and one each in Croatia and Italy. Four studies were one group pre-posttest intervention (41 – 44) studies, and 9

studies were RCT's (23, 28, 45 – 51). Eligible outcome data was available from a total of 292 participants across the 13 studies; 215 were assigned and completed TRAD training intervention, 77 ML training conditions. Interventions lasted an average of 10 weeks (range = 4 – 24 weeks), with an average of 2.7 sessions per week. In 9 studies participants were not receiving any training when in the comparison group and were expected to maintain regular levels of physical activity during the time of the trial (23, 41, 44-49, 51). In 2 studies participants were hospitalized or living in a nursing home (42, 43), one study was performed in a senior citizen center (28). One study described the intervention both in hospitalized patients and in outpatients (50). The traditional core stability training equipment/methods used were: Pneumatic resistance machines (23, 45, 50), resistance machines (43, 44), semi recumbent stepper (23), semi recumbent cycle ergometer (23), Pilates exercise intervention (41, 49), and exercises incorporating core muscles (46, 48). Furthermore, trunk stabilization exercises carried out on a Professional Exercise Ball (28, 42) using elastic bands for dynamic exercises (28), and training with in-gym available equipment and machines (e.g. bilateral leg press, chest press, lat pulldown, seated row machines, dumbbells, dumbbell Romanian deadlifts, bilateral knee extension/flexion seated machine) (47, 51). The ML elements used were dance training with cognitive tasks (47) and a core resistance training device incorporating force modulation exercises that placed an additional cognitive load to the motor task (49) (Table 2). Twelve studies delivered the intervention program in one center-based location (23, 41 – 47, 49 – 51). One study administered a home-based intervention (48). In one study participants could continue their training program after completion of the research in their home environment (41).

From the included thirteen studies, two included a training program that stimulated cognitive function (47, 49) and were categorised as ML. The rationale for this classification was that Hamacher and colleagues (47) used dancing for training, an activity for which learning is the only fast enough mechanism to master such a new task (52). Markovic et al. included feedback-based core resistance training which is known to effect on motor learning (53).

Table 2

Summary description of the included articles

Source	Design	Sample	Exercise intervention	Outcome variable	Results
TRAD training strategies					
Baker et al., 2007 (23)	RCT with one (Exercise) Intervention group and one Control group.	Elderly subjects from a retirement village; 76±6 years old. Allocated to Exercise (n=20), Control (n=18); Completed Exercise (n=14), Control (n=16). Australia.	Supervised Exercise training: F1: 10 wks, 3x/wk; I1: HI 80% of 1RM PRT; Time: 2 sets of 8 reps. Knee flex, ext & hip flex, ext, abd, chest press, seated row, latissimus pull down; Type: Strength Training; F2: 10 wks, 2x/ wk; I2: moderate-intensity (RPE 11 to 14/20); Time2: 20 min; Type2: AET; F3: 10 wks, 1x/wk; I3: n/a; Time: n/a; Type3: PBT. Control group received no intervention.	Chest press, latissimus pull down, seated row, upper body strength, dynamic balance.	Exercise group showed significant increase in chest press strength (Cohen's d=0.65; p=0.04) compared to control group.
Bergamin et al., 2015 (41)	A one intervention (Pilates group pilot study.	Post-menopausal women from a senior citizens center 63±2 years old. Allocated Pilates (n=25); completed training (n=23). Italy.	Supervised Pilates training: F: 12 wks, 2x/wk; I: warm-up with VLI exercises/ only floor. Pilates exercises such as leg circle single leg kick, double leg kick, side kick, one leg stretch, single leg heel, single leg toes, side lying hip abduction, side lying, hip adduction, roll up, rolling back, leg rises on all, fours, pelvic curl and the hundred (2 sets/10 reps for each exercise)/ cool down consisting of stretching exercises; Time: 10min/40min/10min; Type: Pilates training.	Static balance with additional cognitive task, static balance (without cognitive task), abdominal strength, dynamic balance (8 ft up and go test).	Significant improvements on medio-lateral oscillations with eyes-open (ES d=0.7; p<0.01) and dual-task condition (ES d=0.37; p=0.02), 8 ft up and go test (ES d=0.46; p=0.02), abdominal strength (ES d=0.69; p<0.01).
Granacher et al., 2013 (46)	RCT with one intervention (CIT) and one Control group.	Community-dwelling older adults 63 to 80 years old. Intervention group (n=16), Control (n=16); Completers Intervention group (n=16), Control (n=16). Germany.	Supervised Core Instability Strength Training: F: 9 wks, 2x/wk; I: warm-up at moderate intensity/ Exercises in supine, prone, quadruped and side- lying positions. Training intensity progressively and individually increased by modulating lever lengths, range of motion, movement velocity (isometric, dynamic) and level of stability/ instability (3-4 sets per exercise 15–20sec contr time (isometric condition), or 15–20 reps (dynamic condition)/cool down consisting of stretching exercises; Time: 10min /45min /5min; Type: Core Instability Strength Training. Control group received no treatment or intervention. They maintained their normal PA.	Maximal isometric strength of the trunk flexors, maximal isometric strength of the trunk extensors, maximal isometric strength of the trunk lateral flexors (right, left), maximal isometric strength of the trunk rotators (left, right), dynamic balance (Functional Reach test).	Significant increase in the trunk muscle strength in all directions except right rotators (ES f=0.23-1.02; p≤0.05), in dynamic balance (ES f=0.41-0.59; p<0.05) was established in CIT group when compared to control group.

Table 2 (Continued)

Source	Design	Sample	Exercise intervention	Outcome variable	Results
Kim et al., 2014 (42)	One training group intervention with one intervention (Trunk stabilization exercise) group.	Hospitalized elderly people in a geriatric hospital (n=15) 76±10 years old. Completed (n=n/a). Republic of Korea.	Supervised trunk stabilization exercises with Swiss ball: F: 8 wks, 5x/wk; I: Trunk stabilization exercises carried out using Professional Exercise Ball; Time: 20 min; Type: trunk stabilization exercise.	Muscle activation of the rectus abdominis, muscle activation of the erector spinae, muscle activation of the quadratus lumborum, muscle activation of the external oblique.	The muscle activations of the rectus abdominis (ES d=1.95; p<0.05), erector spinae (ES d=1.69; p<0.05), low lateral back (ES d=3,4; p<0.05).
Kim et al., 2015 (28)	RCT with two training groups; random allocation to an isometric (n=10) and a dynamic trunk exercise group (n=10).	Senior citizen center; 20 elderly people in an isometric trunk exercise group (n=10; mean age 73) and a dynamic trunk exercise group (n=10; mean age 73.5).	Supervised exercises performed for 30 minutes 3x/wk for 12 weeks: The isometric trunk exercise program and dynamic trunk exercise program consisted of: five minutes of warm-up exercises, 20 minutes of main exercises, and five minutes of cooldown exercises.	Cadence, cycle time, gait velocity, step time, double support time, stance time, stride length, and functional ambulation performance score were measured.	Isometric strength training: significant differences in gait velocity, left step length, right step length, left stride length, and right stride length (p<0.05). Dynamic strength training: significant differences in gait velocity, cadence, left step time, right step time, left step length, right step length, left stride length, and right stride length (p<0.05). Gait velocity, Cadence, Step length left, and Stride length left change of the isometric trunk exercise group were significantly greater (ES d ranging between 0.33-0.54; p<0.05)
Petrofsky et al., 2005 (44)	One training group intervention with one intervention (The 6 sec Abs machine) group.	Seniors between 61-82 years old (n=13); completed (n=n/a) USA.	Supervised 6 sec Abs maschine training: F: 1 month, 3x/wk; I: passive stretching/4 different trunk strength exercises with workload progrssively increased (weight set such that with repetitive contr of the muscles over 6sec cycles of contr, muscle fatigued in 5min; Time: 10min/20 min; Type: 6sec Abs maschine training.	Strength (kg) of abdominal flexors, strength (kg) of abdominal extensors, balance (Functional reach (cm).	Strength of trunk flex and ext significantly increased (ES d=1.02 and 1.11; p<0.01), the maximal reach in all directions (right, forward, left) significantly increased (ES d=0.65, 1.34, 1.39; p<0.01).

Table 2 (Continued)

Source	Design	Sample	Exercise intervention	Outcome variable	Results
Villanueva et al., 2015 (51)	RCT with one group utilizing short rest interval lengths and one group utilizing extended rest interval lengths	Healthy, recreationally active male seniors 68±4 years old (n=22). In each group (n=11). Completed (n=n/a). USA.	Supervised RT utilising short rest interval lengths in between sets: F: 12 wks, 3x/wk; I: wk 1-4 sets 2 to 4, reps 15 to 8, bouts 4 to 6 exercises, wk 5-12 sets 2 to 3, reps 6 to 4 (performed as fast as possible), bouts 4 to 6 exercises (rest between sets: 60 sec in wk 5-12); Time: n/a; Type: PRT (short rest). Supervised RT utilising extended rest interval lengths in between sets: F: 12 wks, 3x/wk; I: wk 1-4 sets 2 to 4, reps 15 to 8, bouts 4 to 6 exercises, wk 5-12 sets 2 to 3, reps 6 to 4 (performed as fast as possible), bouts 4 to 6 exercises (rest between sets: 4 min in wk 5-12); Time: n/a; Type: PRT (long rest).	Chest press, narrow/neutral latissimus pull down, postural control (dynamic balance).	From wk 8 to 12 strength in short rest group had significantly greater increase in chest press 1-RM (ES d=0.65; p<0.01), narrow /neutral lat pulldown (ES d=0.59; p<0.01) compared to long rest group.
de Vos et al., 2005 (45)	RCT with 3 training groups differing in intensity (HI RT, MI RT, LI RT) and one control group.	Healthy older adults (n=112) 69±6 years old. In each group (n=28). Completed HI RT (n=24), MI RT (n=25), LI RT(n=25), Control group (n=26). Australia.	Supervised RT on Keiser pneumatic maschines: F: 10±2 wks, 2x/wk; I: 4 slow reps at ½RT weight to warm-up before each of 5 exercises (bilateral horizontal leg press, seated chest press, bilateral, leg ext, seated row, seated bilateral leg curl)/each wk 1. RT 3 sets of 8 reps, each wk 2. RT 1RM, 2 sets of 8 reps at I of 20%, 50% or 80% depending on group - HI, MI or LI. Rest between reps 10-15 sec. First 2 RT HI group performed at 50% and 70% 1RM; Time: n/a; Type: PRT. Control group did not undergo PRT, but kept their current level of PA.	Chest press: muscle power, muscle strength, muscle endurance. Seated row: muscle power, muscle strength, muscle endurance.	Chest press muscle power in HI, MI, LI and group (ES d=0.95, 0.94, 1.06 and 0.21; p<0.01), strength (ES d=1.77, 1.06, 1.29 and 0.6; p < 0.01), endurance (ES d=2.00, 1.00, 1.00 and 1.00; p<0.01) significantly increased. Seated row muscle power in HI MI, LI and control group (ES d=0.72, 0.821.40 and 0.22; p<0.01), strength (ES d=1.43, 1.87, 1.19 and 0.35; p<0.01), endurance (ES d=1.60, 1.20, 1.00 and 0.66; p<0.01) significantly increased.
Kahle and Tevald, 2014 (48)	RCT with one exercise and one control group	Healthy community-dwelling seniors (n=26) 65 to 85 years old. Completed exercise (n=12); control(n=12). USA.	Core strengthening home exercise program: F: 6 wks, 3x/wk; I: 8 exercises (Bridging, Reclining curl, Curl-up, Seated oblique crunch, Abdominal contr, Lower trunk rotation, Straight leg raise, Seated marching) each 10 reps (hold of 1 rep 5-25sec). Rest 1–2min between sets. Every 2 wks 5 reps or 5sec hold added; Time: 20min (some did less than 35min); Type: Progressive core stength and endurance training. Control group did not core program, but kept their current level of PA.	Dynamic balance (Functional reach test, Star Excursion Balance Test), core strength (Curl - up test).	Exercise group performed significant improvements in Curl-up (ES d=3.26; p<0.05), Functional reach test (ES d=0.88; p<0.05) and Star Excursion Balance tests in all directions (ES d=0.84-1.35; p<0.05). No significant changes in control group.

Table 2 (Continued)

Source	Design	Sample	Exercise intervention	Outcome variable	Results
Krist et al., 2013 (43)	A one-group pilot study with PRT.	Nursing-home residents (n=15) between 77–97 years old. Completed (n=10). Germany.	Supervised PRT: F: 8 wks, 2x/wk; I: 6 gym maschines (chest press, rowing machine, and butterfly reverse for the upper limb, leg press and leg ext for the lower limb, and a crunch trainer for the abdominals). 3 sets of 8 reps, at least 1 min rest between sets. If lifted more than 8 times in a row all 3 sets, then increased weight 5-10kg; Time: 45min; Type: PRT.	Muscle strength: chest press, rowing machine, butterfly reverse.	Significant improvements were detected in chest press (ES d=1.3; p<0.01), rowing machine (ES d=1.68; p<0.01), butterfly reverse (ES d = 1.5; p<0.01).
Sullivan et al., 2007 (50)	Double-blind RCT with one (LRE + 800mg per day of MA) group, one (HI PRT + 800mg/day of MA), one (LRE + placebo) and one (HI PRT + placebo) group.	Inpatient and outpatient seniors 65 to 93 years old with recent functional decline. (I): LRE + MA (n=7); (II): HI PRT + MA (n=8); (III): LRE + placebo (n=7); (IV): HI PRT + placebo (n=7). Completed (I) + (IV) (n=14), (II) (n=6), (III) (n=4). USA.	Supervised LRE training: F: 12 wks, n/a x/wk; I: warm-up 10% of 1RM/3 sets of 8 reps at 20% of 1RM; Time: n/a; Type: Low resistance exercises. Supervised HI PRT training: F: 12 wks, n/a x/wk; I1: wk 1 20% of 1RM, wk 2 warm-up 8 reps of 30%-40% of 1RM/3 sets of 8 reps 50% of 1RM, wk 3 as high as could for 3 sets with original aim 80% of 1RM, wk 4 at least 80% of 1RM; Time: n/a; Type: High intensity progressive resistance training.	Chest press, cognitive function.	Chest press significantly increased in LRE+ placebo (ES d=0.02; p=0.01), LRE + MA (ES d=-0.05; p=0.01), HI PRT + placebo (ES d=1.28; p=0.01) and in HI PRT + MA (ES d=0.74; p=0.01).
ML training strategies					
Hamacher et al., 2016 (47)	RCT with one health-related exercise intervention group and one (dancing) group.	Older healthy participants' health- related exercise group (n=16, age: 68±3 years old) or a dancing group (n=16, age: 66±3 years old). Completed (n=n/a) Germany.	Supervised Health-related exercise training: F: 6 months, 2x/wk; I: AET (bicycle ergometers), strength-endurance (barbells, rubber band, ball, gymnastic stick, etc.) at predefined heart rates (70% of net max oxy uptake), and flexibility training; Time: 90 min; Type: Health-related exercise training. Supervised dancing training: F: 6 months, 2x/wk; I: Predefined heart rates, set at 70% of net max oxy uptake. Learn 5 genres: Line Dance, Jazz Dance, Rock 'n' Roll, Latin- American Dance and Square Dance. Last 2wks participants recalled learned choreographies; Time: 90min; Type: Dancing training.	Trunk kinematics; Local dynamic stability.	For Local dynamic stability of trunk movements an interaction effect in favour of the dancing group was observed (ES f=0.41; p = 0.02).

Table 2 (Continued)

Source	Design	Sample	Exercise intervention	Outcome variable	Results
Markovic et al., 2015 (49)	RCT with one Huber intervention group and one Pilates training control group.	Elderly women between 66-79 years old, who responded to local newspaper advertisement. Huber (n=17), Pilates (n=17). Completed Huber (n=16), Pilates (n=14). Croatia.	Supervised Huber training: F: 8 wks, 3x/wk; I1: MVC wk 1+2: 50%, wk 3-5: 65%, wk 6-8: 75%; I2: Isometric contr: 5-7sec, 30-60 contr/session without (wk 1-2)/with (3-8 wk) balance perturbations; Time: 25-30 min; Type: Force modulation on Huber machine handles as added cognitive loading. Supervised Pilates training: F: 8 wks , 3x/wk; I: 2-4 sets, 15-20sec contr time (isometric exercise) or 15-20 reps (dynamic exercise) supine, side lying, sitting & quadruped exercises; Time: 60 min; Type: Pilates.	Static balance, static balance with additional cognitive task, trunk muscle strength, upper body muscle strength (Chest press, kg).	Huber training with ML was more efficacious in improving single- and dual-task balance ability (ES d=0.48-0.52; $p<0.05$) and trunk muscle strength in all directions (ES d=0.90-1.11; $p<0.01$) when compared to Pilates. Both groups (Huber; ES d=0.36; $p<0.05$; Pilates, ES d=0.25; $p<0.05$) significantly improved upper-body strength.

Abd abduction, AET aerobic endurance training, CIT core instability strength training, Control contraction, CST chair-sit-to-stand test, ES d effect size Cohen's d, ES f effect size Cohen's f, Ext extension, Flex flexion, F frequency, F2 or F3sec or third type of frequency for the same intervention, HI high intensity, Huber training feedback-based balance and core resistance training, I intensity, I2 or I3sec or third type of intensity for the same intervention, LI low intensity, LRE low resistance exercise, MA megestrol acetate, Max maximum, MI medium intensity, Min minutes, MVC maximal voluntary contraction, N/a not available, Oxy oxygen, PA physical activity, PBT progressive balance training, PRT progressive resistance training, RCT randomized clinical trial, Reps repetitions, RPE rating of perceived exertion, RT resistance training, Sec seconds, Time duration of the exercise intervention, Time 2 or 3sec or third type of time for the same intervention, Type of theexercise intervention, Type 2 or 3sec or third type of type for the same intervention, VLI very low intensity, Wk week, 1RM 1 repetition maximum

Methodological quality of included studies

The agreement on study quality criteria between the two reviewers was 'good' with an estimated Kappa value of 0.74 (95% confidence interval between 0.66 and 0.81). The percentage of agreement between the two raters was 86.9%. Table 3 summarizes the results of the methodological quality assessment for the included studies. The quality scores of studies ranged from 9 to 24 out of a maximum of 28 points. The mean quality score was 15.8 ± 4.9 points.

Table 3

Assessment of methodological quality of included studies using the Downs and Black scale

Source	Risk assessment items																										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**T/P**
TRAD resistance training strategies																												
Baker 2007 (23)	1	1	1	1	2	1	1	1	1	1	0	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	27/28
Bergamin 2015 (41)	1	1	1	1	0	1	1	0	1	1	0	0	1	0	0	1	1	1	1	1	0	0	0	0	0	1	0	15/19
Granacher 2013 (46)	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	1	1	1	0	1	1	0	1	0	0	0	0	14/28
Kahle 2014 (48)	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	0	1	1	1	1	0	1	1	1	1	0	20/28
Kim 2014 (42)	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	9/19
Kim 2015 (28)	1	1	1	1	0	0	0	0	1	1	0	0	1	0	0	1	0	1	0	1	1	0	0	0	0	1	0	12/28
Krist 2013 (43)	1	1	1	1	0	1	1	0	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	1	0	14/19
Petrofsky 2005 (44)	1	1	0	0	0	1	1	0	1	1	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	9/19
Sullivan 2007 (50)	1	1	1	1	2	1	1	0	1	1	0	0	1	0	1	1	1	1	1	1	1	1	0	0	0	1	0	20/28
Villanueva 2015 (51)	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	1	0	16/28
de Vos 2005 (45)	1	1	1	1	2	1	1	1	1	1	0	1	0	0	0	1	1	1	1	1	1	0	0	0	1	1	0	20/28
ML resistance training strategies																												
Hamacher 2015 (47)	1	1	0	0	0	1	1	0	0	1	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	9/28
Markovic 2015 (49)	1	1	1	1	0	1	1	0	1	1	0	0	0	0	1	1	1	1	1	1	1	0	1	0	0	1	1	18/28

P, possible achievable points; T, total points. Risk assessment items, 1 – 10 Reporting, 1. hypothesis/aim/objectives described? 2. Main outcomes described? 3. Participant characteristics described? 4. Intervention/s described? 5. Distributions of principal confounders in each group described? 6. Main findings described? 7. Provision of estimates of random variability in the data for the main outcomes? 8. Reporting of adverse events? 9. Characteristics of participants lost to follow-up described? 10. Actual probability values reported? 11 – 13 External validity, 11. Participants asked to participate representative for population from which they were recruited? 12. Participants prepared to participate representative for population from which they were recruited? 13. Staff, places, and facilities where the participants were treated representative of the treatment the majority of participants receive? 14 – 20 internal validity (bias), 14. Blinding of study participants? 15. Blinding of outcome assessors? 16. If any of the results of the study were based on "data dredging", was this made clear? 17. In trials and cohort studies, do the analyses adjust for different lengths of follow-up of participants, or in case–control studies, is the time period between the intervention and outcome the same for cases and controls? 18. Statistical tests appropriate? 19. Was compliance with intervention/s reliable? 20. Were the main outcome measures used accurate (valid and reliable)? 21 – 26 internal validity (confounding), 21. Were the participants in different intervention groups (trials and cohort studies) or were the cases and controls (case–control studies) recruited from the same population? 22. Were study subjects in different intervention groups (trials and cohort studies) or were the cases and controls (case–control studies) recruited over the same period of time? 23. Randomization, and if yes procedure described? 24. Allocation concealment? 25. Was there adequate adjustment for confounding in the analyses from which the main findings were drawn? 26. Losses of participants to follow-up taken into account? 27 power, 27. Power analysis done a priori? Ratings no = 0, unable to determine = 0, yes = 1; rating item 5: no = 0, partially = 1, yes = 2.

Effect of TRAD and ML training.

TRAD training

The majority of the studies used traditional resistance training strategies to train muscles for core stability (23, 28, 43 – 46, 48, 50, 51) and reported significant pre to post strength gains of chest press in the intervention groups (23, 43, 50, 51) when compared to passive and active control groups, abdominal flexors (43, 44, 46, 48) compared to passive control groups, back extensors (44, 46), latissimus pull-down (51), seated row (43, 45) and butterfly reverse (43). One study reported on gait performance and showed that gait velocity changed more in the isometric trunk exercise group than in the dynamic trunk exercise group (28). The effect sizes ranged between small and large for measures of muscle strength (Table 2). No significant improvements were reported compared with controls in latissimus pull down and seated row exercises in one study (23). Functional measures; e.g. medio-lateral sway, functional reach, balance, etc., showed in general positive changes, however, with large heterogeneity of effect sizes ranging from small to large.

ML training

Two studies that used ML approaches while progressing through the intervention (47, 49) used rather traditional type exercises in their comparison groups. Results from these two studies indicate more improvements in measures of balance and local dynamic stability in the ML groups compared to the traditional types of exercises used. Markovic and colleagues (2015) reported, furthermore, larger improvements for upper body strength measures (49) in the ML training group as compared to the group training more traditional. The quality of these two studies was low (47) and moderate (49) respectively.

A summary of the findings is given in Table 2. Performance of a meta-analysis was not feasible due to the limited amount of two studies identified using ML approaches for training and due to the heterogeneity in study outcome measures used in these two studies. A descriptive summary of the results was carried out in lieu.

Discussion

The purpose of this systematic review was to find an answer to the question “What is the effect of motor learning training strategies compared to traditional strength training for Core Stability on lower and upper extremities use, balance and functional performance in older adults?” The results of our search strategy does not allow giving a conclusive answer to this question in the sense that one approach is superior compared to the other. The majority of identified studies used traditional strength training for

core stability training and no substantial amount of studies assessing the effects of ML training approaches in comparison to TRAD approaches was identified. In addition, 8 of 13 studies interventions were not explicitly focused on the trunk muscle composition's improvements, but rather on lower, upper extremities and trunk parameters (23, 41, 43, 45, 47, 49 – 51). The search strategy led to the identification of many articles from which, however, the majority were targeting core muscles using TRAD trunk strength exercising programmes. The two studies that used elements of a ML approach had a poor (47) and moderate (49) quality and were rather heterogenic considering their outcomes, which, in turn, led to difficulties comparing the results and hindered performing a meta-analysis. The limited availability of high-quality prospective studies that used a comparison between ML and TRAD training approaches warrants targeted future research investigating and comparing the effects of these approaches on lower and upper extremities use and on balance/functional performance outcomes in older adults. Based on our findings we will discuss and suggest directions for future research related to interventions where these two training approaches are contrasted. Through this systematic review, it became apparent that interventions using either TRAD or ML training were both able to effect on lower and upper extremities use and also effected on balance and/or functional performance outcomes in older adults. However, interventions contrasting these approaches were not having a clear enough effect to conclude superiority of either approach against the other.

The number of studies that use TRAD principles to effect on core stability related outcomes form the majority when elderly subjects train core stability. In contrast, the number of studies that use ML based training is negligible. Existing literature on Core Stability exercise using ML principles has been varied in approach, intention and outcome. We continue this discussion by considering the effects of studies applying either TRAD or ML with the aim to effect on lower and upper extremities use and on balance/functional performance outcomes in older adults. Practices of TRAD & ML interventions are discussed together with the underlying mechanisms that theoretically would explain the effects of the used intervention components.

Those studies, that targeted core stability directly with TRAD training showed significant improvements both in trunk muscles strength and dynamic balance. Scanty evidence of ML integration in core training programs might be explained by findings that indicate discrepancies in outcome measurements when investigating the effect of cognitive involvement in exercise programs. For instance, Schoene and colleagues revealed that interactive cognitive-motor interventions (which require

participants to interact with a computer interface via gross motor movements) appear to be of equivalent efficacy in ameliorating fall risk as compared with traditional training programs (17). Such interventions are, furthermore, able to improve cognitive functioning in both clinical and non-clinical populations (54). However, core stability was not under the scope of neither of these reviews. Spinal locomotor ('central pattern generator') as well as non-locomotor activity are both under supra-spinal control (29). Motor skill training has the potential to allow the brain relearning and reintegrating of the timing and sequencing of movements together with the postures and phases of gait (18). It is in this context that efficient patterns of brain and neuromuscular activation might be able restoring the energy efficiency of movements. Restoration of energy efficiency would make walking easier because of adaptive changes in the brain attributable to motor skill training (55 – 57).

Our review found two RCT studies using a ML training approach (47, 49). Such an approach would make sense considering that muscle actions must be precisely coordinated to occur at the right time, for the correct duration and with the adequate combination of forces (58). Coordinated muscles activation improve stabilization of the trunk (59) that is crucial for maintaining static or dynamic balance (60). Considering ML approach to elderly patients, it might beneficial if "movement memory" element is applied to the program. One of the ML training approach study's intervention was based on learning and remembering specific dancing skills, making sure that the participants learned something new in each session (47). The second was Markovic's study where a special Huber device with an interactive interface and balance platform was used (49). These ML training approaches (47, 49) did not disturb the external focus of attention by diminishing visual input. Such an approach would make sense considering that older persons frequently fall or trip on objects below eye level (61) and there is evidence, that orientation input from the ankle appears to have greater importance for preventing falls compared with a visual reference (62). Furthermore, in the absence of visual feedback (or partly of level 2 by Radebold (31)), poor balance performance correlates significantly with longer trunk muscle onset times in response to sudden force release in those with chronic back pain (31). This underlines the importance of sensorimotor coordination without visual feedback between trunk muscles and supra-spinal centres (e.g. level 3 that ensures so-called anticipatory postural adjustments to maintain the balance).

Specific motor control training as part of core stability training protocols for older adults can, furthermore, be justified by the observation from a recent systematic review evaluating the effectiveness of motor

control exercise targeting core muscles in low back pain patients that favored motor control exercises against general exercise because of superior pain and disability outcomes (63). Normal motor control in the lumbar spine is important because of the observed maladaptive differences seen between people with and without core muscles related disabilities in relation to feed forward mechanisms (64, 65), reduced core muscles cross sections (66, 67) and altered cortical representations of motor patterns (68). Furthermore, both neurogenic and myogenic factors occur in aging leading to muscle weakness and impaired functions (69, 70). From this it can be hypothesized that the training of motor control is an important component of core stability training in older adults. However, as the results from our systematic review indicate so far there is no clear and extensive mechanistic and randomised controlled trial based data supporting the rationale for ML for core stability training in older adults?

Therefore, studies investigating ML in combination with core stability exercises are warranted.

It is striking that our review revealed one study only that focused on gait function as outcome for training in elderly individuals (28). This notwithstanding that there is a clear assumed relationship between trunk muscle activity and lower extremity movement (21). Training invoked variations in the efficiency with which motor actions can be generated influence the stability of coordination (25) and the assumption that different types of core muscle training will effect differently on physical functioning seems justified. From a theoretical perspective, it can be hypothesized that more traditional forms of resistance training improve gait speed (13) as also shown in some of the manuscripts (28, 41). However, such traditional training will not influence variability measures of gait. Variability of gait in older adults is associated with areas important for sensorimotor integration and coordination (71) implying that motor skill training components that target these areas as part of an intervention should be included in training programs (18).

Limitations of the study

Several limitations of this review can be identified. It is possible that some research studies have been missed, because these were not published in the main databases we searched, because of non-English language publications, or being not referred to by other articles. Studies published in languages other than English were not included. Because randomized and non-randomized study designs were both considered in our review we referred to the Downs and Black list (39) for study quality assessment. This list has a drawback in the sense that the ability of the Downs and Black scale differentiating studies containing potential sources of bias is limited (72).

Furthermore, the scoring of the methodological quality of the included studies is not entirely clear since there is no clear cut-off point known for the purpose-adjusted list for the assessment of the methodological quality of both randomized and non-randomized studies. It is difficult, therefore, to give clinically relevant meaning to the scores of the studies included in this review.

Conclusion

The number of studies that use TRAD training approaches for core stability training with the aim to effect on use of the lower and upper extremities and improved balance/functional performance outcomes in older adults form the majority. In contrast, the number of studies that use ML approaches is small. Existing literature on core stability training has been widely varied in approach, intention and outcome. Currently available literature does not present a wealth of information about the best strategy for core stability training in subjects older than 60 years. Evidence-based clinical applications of TRAD & ML methods are, therefore, in need of (further) development. Our findings indicate that the challenge for the various developed training programs is evaluation of transfer effects in "real life" settings. Before selecting an exercise program clinical practitioners should formulate clear goals of measuring program effects in clinical settings in order to receive credible information about the best suited program.

Conflicts of Interest

Agris Liepa, Ruud Knols, Viesturs Larins, Federico Gennaro and Eling de Bruin declare that they have no conflicts of interest relevant to the content of this review.

Authors' contribution

AL, RHK and EDB developed the research question. The concept and design part was established by AL and RHK while EDB acted as methodological council. AL, EDB and RHK did data acquisition as well as, together with FG, analysis and interpretation of the results which was edited and improved by VL & EDB. AL and RHK produced an early version of the manuscript. FG and EDB substantially revised the manuscript to bring it to its current version. All authors have read and approved the final manuscript.

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Compliance with Ethical Standards

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Abbreviations

ML: motor learning training, TRAD: traditional training.

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REVIEW PAPER

IMPLEMENTATIONS OF TACTO SOFTWARE FOR ANALYSING ATHLETIC EFFECTS OF PARKOUR ON YOUTH FOOTBALL PLAYERS' PERFORMANCE

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Abstract

Improving Social Interactions, learning skills, health and confidence can be achieved through sport and motor development. Young athletes can adapt to new situations and learn various skills quicker than older athletes. The aim of the present study was to investigate the effect of parkour on youth football players' performance using Tacto software. Tacto software can evaluate players' motor skills in sporting environments. To conduct this study, 10 youth players of 8-10 years of age from the professional football club of Sheffield United Academy were selected. The players were asked to take part in 6 sessions of parkour practice. Their football performance was recorded using a 2D camera in indoor 5-a-side football matches prior to and during parkour sessions, and after the last parkour practice session. Tacto software was used to extract the players' performance parameters included velocity, displacement and acceleration from the recorded tapes. The performance parameters were analysed using SPSS and Excel. The results of paired t-test show significant differences in velocity, acceleration and displacement between football matches before parkour practice and after 6 sessions of parkour. Overall, football players' performance improved after they became familiar with parkour and it is anticipated that spending more time practicing parkour will result in the players' greater improvement and will ensure successful outcomes.

Key words: *Parkour, Tacto, Paired t-test, Youth athletes, Sports, Dyadic system*

Introduction

The results of the study by Biddiss and Irwin (2010) have suggested that recently a high percentage of children prefer to spend their free time on sedentary activities, and a child of 8-10 years of age typically spends more than one hour per day playing video games. These habits could be the cause of obesity and reduced physical activities in children. Sports are one of the best ways to improve children's social interaction, learning skills, health and confidence and they are highly beneficial for motor development. Moreover, youth athletes can adap to new situations and learn various skills quicker than older athletes (Tustin, 2018). A coach's responsibility is to develop athletes' mentality, techniques related to desired sport and decision making skills. Coaches must be cautious not put youth athletes under more than necessary pressure, and they have to improve their training designs and analyse athletes accurately. A valuable and effective behaviour to control stage along with players' displacement coordination of players learning is exploratory practices (Araujo et al., 2015).

For example, in football, all of the positions require special coordination and body awareness skills, and parkour is advantageous because it engages both body muscles and the brain (Smyth & Anderson, 2001).

Parkour is beneficial for athletes that challenged to negotiate obstacles of various natures during practice to improve their athleticism. Moreover, parkour is advantageous to the improvement of athletes' creativity during physical activities because in this sport athletes are continuously faced with surfaces of various textures, angle and sizes in different environments and combine movements to the key informational sources (Miller & Demoiny, 2008). Parkour influences initial velocity, improves the athletes' agility and teaches athletes to decide quickly in different or new situations. Another effect of parkour on athletes is existing to space to perform the exercise. This means that after practicing parkour, athletes do not need to take some steps back in order to jump further (Atkinson, 2009). Therefore, it is an effective method to design training sessions based on this sport to improve players' initial speed of mobility and movement in football, especially to catch the ball in 1v1 competition. In addition, players can improve their ability to prevent injuries from pushing or tackle by opponent during physical activities or matches. To study the effect of parkour on football players' performances, Sheffield United FC (a professional club in England) youth football players were selected as participants in this project.

Tacto is a software that analysis athletic performance, analyse the development of players on some skills such as team relevant velocity, total

displacement, average velocity and acceleration of each team, body awareness, interpersonal displacement and compare values between the players or teams ((Edgecomb & Norton, 2006) & (Serrano & Fernandes, 2011)).

The aim of this study was to investigate the effect of parkour on the performance analyse the individual skills of the youth football players from Sheffield United Academy. The players' performance was recorded by a 2D camera during friendly 5-a-side matches and all the parameters were extracted using Tacto software. It was expected that parkour be highly beneficial in the improvement of athletes' agility, high-speed actions and creativity in different conditions, and thus, rapid decide making. Tacto software was applied to extract the performance parameters and analyse the results.

Material and methods

The participants consisted of 10 experienced football players (age: 9±1 years) from Sheffield United Academy. The benefits and positive effects of parkour skills were explained to the Academy coaches by a professional. In addition, Tacto software was demonstrated to the coaches and the method of value measurement by Tacto was described to them. After they accepted to use and teach parkour skills to their players, the Academy prepared a form to explain the procedure to players' parents and obtain their permission for this task. All players' parents signed an informed consent attesting the teaching of parkour to their children and recording of their matches for the study. Players were divided into two teams of 5 players that were called Right-team and Left-team throughout this study. They asked to play 4 minutes' football match in 20 x 15 meters football field. The warm up with parkour was performed in 6 individual sessions each lasting 30 minutes. The warm up was incorporated into their weekly training sessions. Practice football matches on artificial field were played before teaching parkour (beginning of the process), after 3 sessions of parkour (the middle of the process) and after the final parkour session (end of this process). The players' motion was captured using a digital video camera. In the process of calibration, 6 cones (as signs) were placed inside the pitch by following an imaginary square. Then, 2 participants were requested to have a 1v1 competition to check the coordination on the x and y axis before the match. The dimension and order of each cone for calibration is shown in figure 1. Tacto digitising action was 25Hz for extract data on player displacement coordinates.

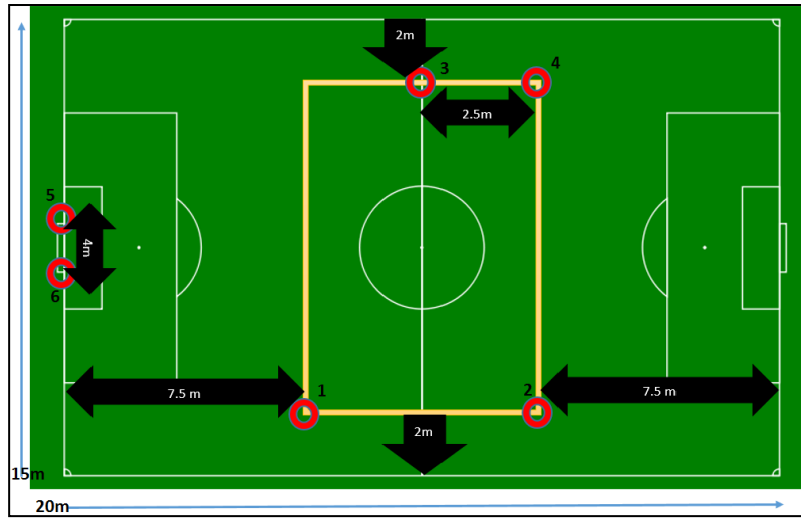

Figure 1. Dimension and place of the cones in the pitch
(Each cone would be a control point to calibrate the pitch in Tacto. The numbers show the order of selection of the calibration points)

After placing the cones as signs to calibrate the camera, the players' movement trajectories were captured by a digital speed 2D camera. The camera was placed on an elevated plane with 6 meters' height, forming an angle of 45° with the linear (y) axis of the selected area (Duarte et al., 2012). In the next step, the computer mouse arrow was placed between each player's feet and the players' movements were manually followed. Tacto was used for image treatment and digitisation of the videos at 25 frames per second (Fernandes & Malta, 2007). The study by Duarte et al. (2012) showed that the cameras with this amount of Hz are suitable for analysis in Tacto software.

Subsequently, data on the velocity, acceleration, displacement and position of each player in all trails were computed with Excel. The process of calculating the variables is presented in the 'Data Processing' section. The average values of all participants were used to measure their performance enhancement. The data of displacement trajectories of youth players was manually digitised with Tacto, and bi-dimensional pixel coordinates were obtained (Fernandes et al., 2010). The x and y direction of players in a period of time was measured by Tacto.

The formula for the Pythagoras theorem was used to measure the total displacement in each period of time. The equations used to measure displacement, velocity and acceleration are presented below:

$$\textbf{Displacement} = \sqrt{x^2 + y^2}$$

Equation 1. Pythagorean equation (This equation is equal to the sum of the squares of the other two sides; in this study the two other sides are the two axes in x and y direction).

$$V = \Delta x / \Delta t$$

Equation 2. An object's average velocity over a period of time (In this equation, V is the average velocity, **Error! Reference source not found.** is the change in displacement and **Error! Reference source not found.** is the duration of time).

$$a = \Delta V / \Delta t$$

Equation 3. An object's average acceleration over a period of time (In this equation, *a* is acceleration, **Error! Reference source not found.** is the change in velocity and Δt is the duration of time).

By correlational running of football players, it was possible to measure two types of coordination tendencies: (i) The coordination of each player during matches and the interpersonal interaction of a defender head-on an attacker; and (ii) The average relative velocity, displacement and acceleration of all players as a team during three different matches. The second type was used to analyse the players' performance enhancement.

The study of the interpersonal interactions of 1v1 competition (attacker–defender) dyads for the football players was based on the study by Passos et al. (2013). In this sub-phase, an attacker tries to dribble the defender and defender tries to block the ball. The variable of relative angle illustrates whether the attacker was successful or not when their distance is less than 4 meters (Duarte et al., 2010). Relative angle is an imaginary angle between attacker, defender and the centre of the goal target and calculated by using equation 4.

$$\theta(t) = \arcsin\left(\frac{(Y\text{attacker} - Y\text{defender})}{\sqrt{(X\text{attacker} - X\text{defender})^2 + (Y\text{attacker} - Y\text{defender})^2}}\right)$$

Equation 4. Calculating relative angle between attacker, defender and centre of the goal target.

The angles close to 90° signified that the attacker was on a hypothetical perpendicular line with the defender. Decrease in the angle value shows that the attacker tried to dribbled the defender. However, after the attacker passed the defender, there were two possible occurrences. The first possibility was that the attacker passed the defender without any contact that means the attacker was successful in dribbling the defender. In this situation, the angle values continuously decreased up to around -90° and the attacker moved toward the try line. The second possibility was a contact between defender and attacker. In this situation, there were fluctuations in angle values and the cessation of fluctuation meant that either the defender had tackled and blocked the attacker, or the attacker had avoided a contact

with the defender (for example, had passed the ball to another teammate). If the relative angle never decreases up to 0°, it means the attacker could not pass or dribble the defender or the defender did not allow the attacker to pass him.

Another variable that was analysed in this study was the fluctuation rate of relative angle position between the attacker and the defender. This variable showed which of the 3 situations was the appropriate outcome of the attacker-defender encounter: (i) the attacker successfully tackled and blocked the defender; (ii) the defender was unsuccessful in tackling the attacker; and (iii) the attacker destabilized the dyad. The fluctuation rate of relative angle was measured by central finite differences approximation of derivatives for a given time that already measured in Tacto.

$$(d\theta(t))/dt = (\theta(t1 + \Delta t) - \theta(t2 + \Delta t))/(2.\Delta t)$$

Equation 5. The formula for the calculation of the fluctuation rate of relative angle position between the attacker and the defender.

Phase space graphs are drawn to identify the existence of chaotic attractor in time (Brown & Henkel, 1995). In These graphs, the x and y axes, respectively, represented the defender–attacker vector values and the players' first derivative. These nonlinear tools helped the analysers to recognise the variability and complexity analysis for each coordination pattern.

The statistical analyses were conducted in SPSS software (Version 22.00, IBM Corporation, Armonk, NY, USA). Using Kolmogorov-Smirnov test, the normality of the data was assessed before any further data analyses (Field, 2013). The normally distributed data were analysed through parametric methods. Paired t-test was used to compare the youth players' mean values of displacement, velocity and acceleration between: (i) before teaching parkour and after 3 sessions of parkour (middle of process); (ii) before teaching parkour and after the final session of parkour; and (iii) after 3 sessions of parkour and after the final session of parkour.

Results

The variables were collected for each practice session and compared by using paired t-test in SPSS software. In the statistical analyses, each parameter value for each session was compared with that for other match sessions. Tables 1 to 3 show the differences in mean, standard deviation, standard error of the mean, confidential interval, t-test value, degree of freedom and level of significance for the velocity, acceleration and displacement of all players. In the level of significance column, values of less than 0.05 illustrate that the differences between the two compared sessions in the related variable were statistically significant (Tables 1 to 3).

Table 1

Paired t-test statistical analyses of all of the players' velocity improvement as one team during three practice match sessions

		Paired Differences					t	df	Sig. (2-tailed)
		Mean difference	SD	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre_test - Mid_test	-0.265	0.049	0.035	-0.709	0.179	-7.571	1	0.084
Pair 2	Pre_test - Transfer_test	-0.755	0.077	0.055	-1.453	-0.056	-13.727	1	0.046
Pair 3	Mid_test - Transfer_test	-0.490	0.127	0.090	-1.633	0.653	-5.444	1	0.116

(Each session was compared individually with another session and only the variables with a significance level of less than 0.05 (2-tailed) had differed significantly).

Table 2

Paired t-test statistical analyses of all of the players' acceleration improvement as one team during three practice match sessions

		Paired Differences					t	df	Sig. (2-tailed)
		Mean difference	SD	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre_test - Mid_test	-0.0030	0.0002	0.0002	-0.0055	-0.0004	-15.00	1	0.042
Pair 2	Pre_test - Transfer_test	-0.0035	0.0002	0.0002	-0.0060	-0.0009	-17.50	1	0.036
Pair 3	Mid_test - Transfer_test	-0.0005	0.0005	0.0004	-0.0055	0.0045	-1.250	1	0.430

(Each session was individually compared with another session and only the variables with a significance level of less than 0.05 (2-tailed) had significantly differed).

Table 3

Paired t-test statistical analyses of all of the players' displacement (total distance that they had ran) improvement as one team during three practice match sessions

		Paired Differences					t	df	Sig. (2-tailed)
		Mean difference	SD	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre_test - Mid_test	-168.6	24.3	17.2	-387.6	50.4	-9.7	1	0.065
Pair 2	Pre_test - Transfer_test	-211.1	19.8	14.1	-389.7	-32.5	-15.0	1	0.042
Pair 3	Mid_test - Transfer_test	-42.6	44.2	31.2	-440.2	355.1	-1.3	1	0.403

(Each session was individually compared with another session and only the variables with a significance level of less than 0.05 (2-tailed) had differed significantly).

Figure 2 shows the patterns of interpersonal dynamics in 1v1 defender-attacker dyads in football. The left side of figure 2 illustrates the situation in which the defender tackled the ball and successfully stopped the

attacker and the right side of figure 2 illustrates the situation in which the attacker was successful and dribbled the defender. In figure 2, the A and D sections represent the collective variable against time, sections B and E represent the plot of first derivatives against time, and C and F represent the phase space illustrating collective variable as x axis and first derivative as y axis. As can be seen in figure 2, in cases in which the defender was successful, the collective variable had a positive value and the first derivative had a negative value. The opposite was true when the attacker was successful.

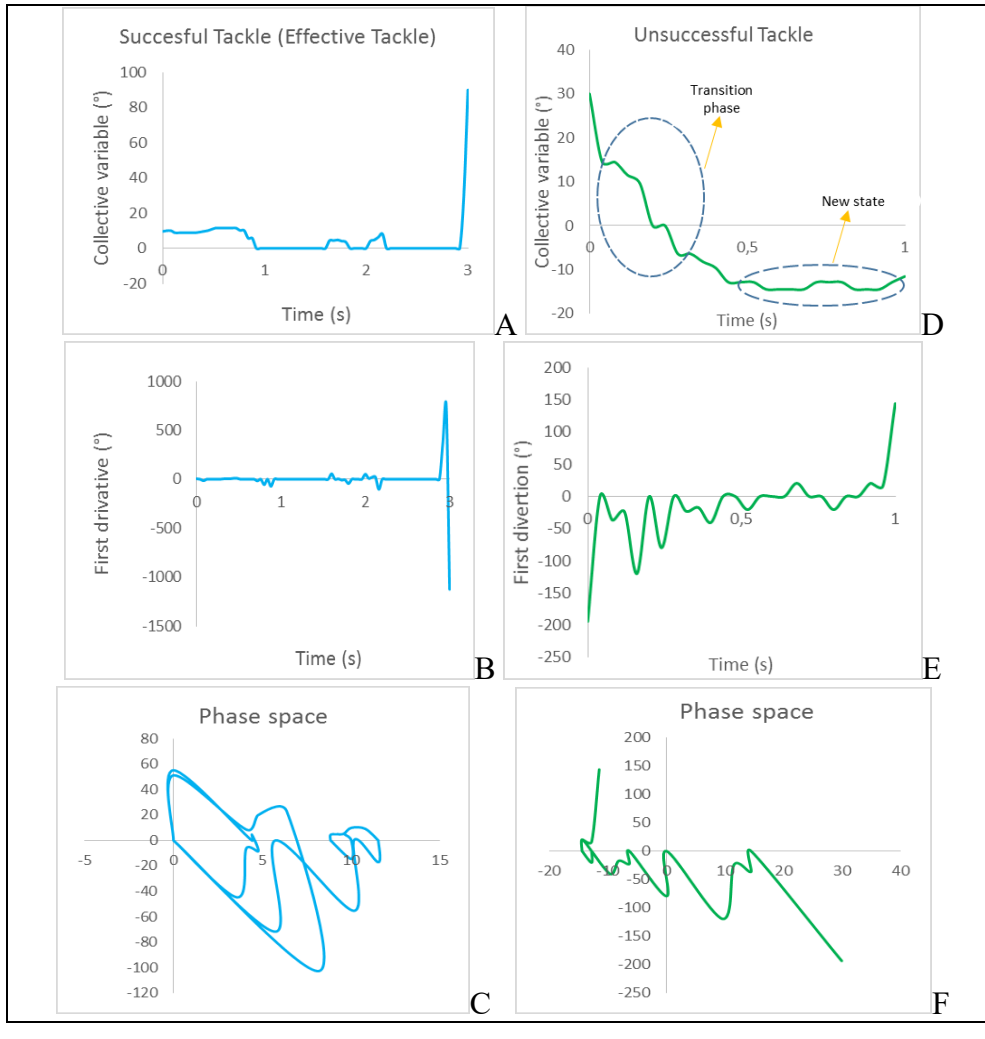

Figure 2. The left side of the figure shows a successful defender and the right side a successful attacker. Sections A and D show the collective variables against time, B and E show first derivatives against time, and C and F show phase space.

The last graph (Figure 3) is an example of the comparison of the teams' total displacements and average velocity during the mid-test session. From this graph, the performance of the teams can be understood during a whole 4-minutes match and at each second of the match, what team was more covered the pitch.

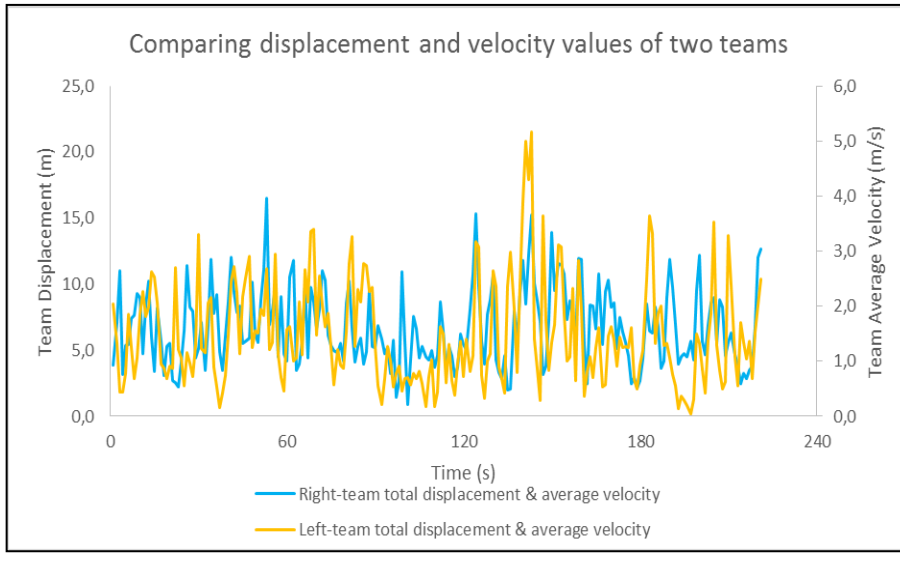

Figure 3. The displacement and the velocity during the whole 4 minutes' match in the mid-test session for the two teams. The yellow lines were for left team and blue line for right team.

Discussion

After data collection and analysis using SPSS software, data shows that the significant values of average velocity, acceleration and displacement for all players between the pre-test and transfer-test were reliable (0.046, 0.036 and 0.042). In addition, the difference in acceleration between pre-test and mid-test was also significant (0.042). These results showed that all the players' performance enhanced significantly by learning parkour skills. In all 3 parameters of velocity, acceleration and displacement, the differences were significant between before and after parkour introduction. This could be due to learning new parkour skills; the players' body awareness helped them to have more open minded during the match, and thus, they tried to cover more parts of the pitch in order to block the opponent.

Conclusion

Tacto is a performance analysis system that makes the comparison of 2 teams or 2 players possible. Tacto is an accurate method and many variables can be measured and analysed with it. After collecting players'

movements in x and y axis by using Tacto, with mathematical skills and engineering knowledge it is possible to achieve the data requested by the analyser or the coach.

The overall results showed that by introducing parkour skills to the warm up session of youth football players, their performance were enhanced. Young athletes can have more parkour training sessions to achieve more success and run longer distances and faster, improve their body awareness and prevent injury. Furthermore, coaches can use Tacto software to analyse variables such as interpersonal interaction in order to design further training sessions and become familiar with the weaknesses or strengths of their players and how to arrange the players for the matches or different training systems. In addition, the coach can evaluate the players' performance individually, and for example, if one player runs much more than his teammates, the coach can divide their roles in a way to maintain balance in the team if needed.

Practical Implication

- Parkour is an effective method to enhance athletes' performance.
- Tacto is a method to analyse athletes' performance.
- Matlab or Excel are the assistant software to analyse the collected data in Tacto.

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REVIEW PAPER

CREATE NOT AN EVENT FOR FANS, BUT FAN'S EVENT: MANAGERIAL ASPECTS OF SMALL-SCALE EVENTS

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Abstract

This paper argues the merits of hosting small-scale rather than large-scale sport tourism events. First, distinction between large-scale events and small-scale events will be drawn. Next, along with emphasizing potential markets for hosting small-scale sport tourism events, argument that there is a need for hosting those types of events will be introduced. Following provided arguments, the developmental issues surrounding sport tourism events will be discussed. Issues of commodification and authenticity will be explored in greater detail.

Keywords: *small-scale events, mega events, sports tourism, sports tourism customers.*

Introduction

Events are significant part of modern day leisure industry as they are organized in all industry sectors. Travel and tourism, sport and recreation, lodging, restaurant, entertainment and education sectors stage the events in order to attract visitors. Be it an exhibition, circus, high school reunion party or scouts camp, Olympic games or regional juniors swimming championship, all these events have an element of attraction that brings people together to enjoy it. Sport has been one of the main attractions of

events. Since time immemorial people were interested in sporting events. First Olympic Games were held in 776 B.C., various religious and ethnic celebrations were main attractions for people to gather in the Middle Ages. What differ today are events' periodicity, place and theme.

Rapid growth of media attention resulted in staggering growth of caliber of sporting events. As a result, mega events such as Olympics, FIFA World Cup, Super Bowl, Baseball World Series have emerged and now create spectacular bonanzas for live and TV audiences. The attention is so magnificent that event not only draws TV and social media attention, it also makes people travel to its location in order to experience it live. As a result, sports events have become large tourist attractions.

Nonetheless, sports events as tourist attraction are ever evolving and growing. As Green (2001) notes, sports events organizers, in addition to sporting spectacle, are offering enhanced activities and services. It is important to recognize as many visitors' needs as possible, thus, making an event more appealing. For example, NBA Draft has now become one of the main annual events in basketball, alongside with All-Star Game and the Playoffs. League has realized fans' and media interest in draft and from 1992 has started to host this event in different cities each year (before it was held in New York). It is now held in crowded NBA arenas, broadcasted live in prime time and draws tremendous amount of media and fan attention from all over the world (National Basketball Association, 2000).

In light of all these merits that sports events have, it is safe to say that event sport tourism is emerging and very prominent component of sport tourism development. In fact, event sport tourism is increasingly being tied up with economic activity and development plans of regional and national governance (Gibson, 2017). Although not unequivocally shared, notion of economic benefits yielding from staging sporting events is legitimate and very strong (Turco & Lim, 1998; Gratton, Dobson & Shibli, 2000).

However, an important distinction, on whether an event is spectator or participant, arises while organizing and promoting sporting event. Interestingly, according to Hinch and Higham (2004), spectator driven events tend to be elite sport (and, thus, of larger scale) events, whereas participant driven sports events are mostly non-elite and have smaller scale. A lot of research has been done on large-scale elite sport events (Hinch & Higham, 2004) but not much has been done in regard of small-scale events. Nonetheless, few authors suggest that smaller events can be particularly attractive and bring substantial benefits to host community (Green & Chalip, 1998; Hinch & Higham, 2004). Destinations, which are not able to host mega events due to capacity constraints, could and should compete for hosting smaller scale events instead. Such events can be comparatively

inexpensive to organize; nonetheless, they can attract large numbers of people to a city or region. Due to this high benefit to cost ratio, it is worthwhile examining the traits of small-scale events.

As mentioned, smaller scale events do not usually offer high quality spectacle, but rather invite people to participate and get more actively involved. This important distinction is very significant upon understanding the motivations of potential visitors. It is not only distinguishing potential customers into spectators and participants, but also realizing that participants differ amongst themselves as well. The latter distinction will also shed light on visitor motives. According to Hall (cited in Hinch & Higham, 2004), actively involved event visitors can be classified into activity participants and players. Both differ in their goals of attending the event, views and pursue of physical activity, with former having more casual attitude towards the competition itself and seeking more general fun and active leisure time, whereas the latter group of visitors is usually deeply committed to the sport and seek quality competition. As a result, every event has its own market and consumers that need to be recognized and targeted.

The objectives of this paper are to discuss main characteristics of small-scale events by parallel contrasting of mega events; to describe markets and consumers of small-scale events; and to outline the key developmental issues of small-scale events management.

Material and methods

In order to fulfill previously stated objectives a method of systematic review of the literature (Cooper, 1989) on sport tourism and related terms for managerial aspects of event organization was utilized. Using a positivism paradigm the purpose of the search was to synthesize the results of a number of studies regarding the small-scale events. The ability to provide a specific, cause-and-effect type of answer is the most advantageous use of such methodology.

The literature search was performed during the fall of 2018 using the following databases: EBSCO, SPORTdiscus, ProQuest, Academic Search Complete. Each database was searched from the earliest to the most relevant date available and the selection criteria included peer-reviewed journals, written in English, available as full-text, related to sport tourism and sport event management. Additional studies were identified using hard copies from personal libraries. The selection criteria were independently applied by all three researchers. In case of the initial disagreement, discussion of an article ensued until a consensus was reached.

Results

Characteristics of Small-Scale Events. When discussing events and event management, many authors fail to draw an important distinction between large-scale events and small-scale events. It has been done so mainly because of very subjective nature regarding this type of definition. As a result, different authors apply different criteria for events' definitions. Most commonly used phrases include Olympic Games, World Cup, World fairs fall under the category of mega-events, which are "large-scale, high-profile occurrences of limited duration intended to attract attention and visitors to a host city" (Burbank, Andranovich & Heying 2002, p. 183). However, most of them fail to specify how large or what is the capacity of the profile.

As Getz (1997, p. 6) argues, "it is really more a question of the relative significance of an event, rather than any particular measure of its size or reach." Thus, it is important to overview what constitutes to the significance of the events.

One of the main definitions of an event is the number of people involved. Mega events are usually coherent with large spectator crowds. As Getz (1997) mentions, mega means 1 million in the metric system, thus, the event has to attract one million visitors. However, it could be argued that one million visitors are way too much in order for an event to be recognized as mega event. For example, one-time event is held in a stadium, no facility could accommodate one million fans. Super Bowl is widely considered a mega event, even though it is held in front of a crowd that does not exceed one hundred thousand spectators.

Also, when speaking of number of visitors, one has to distinguish between participants and spectators. Some events are designed for participants rather than spectators. It would be hard to stage an event involving one million participants (and as a result award mega status to it), but the most popular marathons, such as Boston and New York, could easily be named mega events. As a result, number of visitors is not the only criterion for defining size of the event. Also, deciding on actual number of visitors is a subjective matter.

Another important distinction that separates large events from small ones is media attention. No mega event could go by without extensive media coverage; live broadcast is imperative as well as a large presence of media representatives. The popularity and the widespread of social media channels add another dimension to coverage of event. Social media platforms enable not only sports broadcasters, but also athletes and fans to create valuable, dynamic and interactive content, which brings more attention to the event.

Number of authors (Getz, 1997; Burbank, Andranovich & Heying 2002) stress the importance of economic impact in defining mega events. Economic impact involves series of separate issues. First, costs associated with staging of the event create significant difference between mega events and small-scale events. Mega events distinguish in multi million expenditures that start long before actual event. One of the main features is bidding process (Whitelegg, 2000). Smaller scale events do not have to commit any financial resources on bidding process, as well as on building large infrastructure. Mega events on the other hand are always associated with considerable facility constructions. Hundreds of millions of Euros for new stadiums and other sporting facilities are common features of modern day mega events.

Second, economic profit that the event generates separates mega events from small-scale events. Due to large media presence, event's significance and prestige, mega events greatly attract tourists to the area. Also, corporate sponsorship involvement is of much bigger scale in mega events.

Another significant issue regarding differences between mega events and smaller scale events is the physical presence of the event that transforms entire community. Usually large events disrupt everyday routines and embrace all local community, whereas small-scale events sometimes can pass unnoticed by some members of local community. Palmer (1998) presented the impact of Tour de France on local villages as she explained how image of the event was used by local businesses, how every village welcomed and was prepared for the race. Palmer concluded that "in every possible way, 'normal' life is suspended or displaced to accommodate the 'abnormality' of the Tour de France." (p. 268).

Sport tourism scholars (Green & Chalip, 1998; Higham, 1999) agree on growing demand for hosting small-scale events. Smaller communities that lack size and necessary infrastructure to host mega events are bound to settle for smaller scale events. However, as mentioned earlier, small-scale events do not necessarily mean less interest among visitors or more modest financial success. It is argued that cost to benefit ratio of small-scale events is very high. As Higham (1999) states that small-scale events present great opportunities for managers to perform business and avoid all the complicated issues that surround mega events. He clearly explains the advantages of small-scale events over mega events. Starting with bidding process, building infrastructure and other economic constants that carry particularly high-price tag in mega events, Higham also explains negative impacts of mega events on social life and destination image. In contrast, the organizers of small-scale events do not have to spend high amount of

financial resources on bidding process, infrastructure is usually in place and only minor renovations could be needed that will serve community after the event. Also, financial burden of hosting the event is not placed on local taxpayers. Crowding and security issues do not affect small-scale events as much. As a result, local residents will not try to leave the area in order to avoid traffic congestions and so on. Interesting point raised by Higham is related to destination image. Mega events draw so much media attention that it carries certain risks. In case event proceeds unsuccessfully or is associated with negative incidents (such as criminal accidents, terrorist attacks, etc.) because of extensive media presence, negative news will be released and area's image could be severely damaged. Small-scale events are not that broadly covered by the media and so has a lesser degree of risk of getting negative destination image.

As mentioned earlier, prestige is closely related to mega events. Due to broad media involvement and great national and international exposure, mega events are associated with destination's prestige and image creation. Also, as could be seen from the global events (social vs. capitalist regimes) of the last few decades, mega events can become tools of governments and political ideologies (Roche, 2000). In conclusion mega events could be defined through Getz' (1997) description, which was similarly reiterated by Muller (2015) and stated that large number of tourists, big media coverage, large costs and infrastructural changes define mega events.

Small-scale events, on the other hand, could be defined in sharp contrast to mega events. Modest spectator or participant crowds, smaller scale involvement of media companies and significantly lower financial investments, as well as profits accompany small-scale events. However, as will be argued further, smaller scale does not necessarily mean less opportunities or worse grounds for staging.

Sport Events Markets. Understanding potential markets is as equally important in sport tourism, as it is in other businesses. Tourist motives are likely to be multiple. As a result, one is looking at a complex web of interrelated interests and motives that need to be separately highlighted and assessed. Market segmentation represents one of the central topics which tourism researchers and practitioners have repeatedly investigated. As Hinch and Higham (2004) explain about sport tourism development markets, they provide us with a set of questions, such as 'Who are sport tourists?', 'What factors motivate sport tourists?', 'To what extent do motivations differ between distinct groups of sport tourists?', 'What travel experiences do sport tourists seek in association with the sports that they pursue at a given destination?' Upon answering these questions, one will be able to identify appropriate market segments and target them. As can be seen, the most

important object here is to know your customers and, more importantly, to understand what motivates them to come and attend particular event. Crompton and McKay (1997) extensively studied the motives of visitors who attend festival events. According to them, understanding visitor motivations is important for three reasons. First, it allows organizers to make better and more focused offers to potential customers. Also, it helps to better satisfy customers' needs. Finally, knowing what motivates visitors to attend one event or another helps to better understand customers' decision-making process.

As Hinch and Higham (2004) explain, upon segmenting sport tourism markets it is necessary to define the demand groups among your clients. For example, Maier and Weber (cited in Hinch & Higham, 2004) identify demand groups based on the level of intensity that visitors engage themselves into the sporting activity. Therefore, all four groups (from top performance athletes to passive sports tourists) are interested in sports events, nevertheless in different ones. Top performance athletes will seek for a high quality competition, occasional sportsmen will combine sporting activities with cultural sightseeing or other interesting things to do, and passive sports tourists will be mostly concerned with watching sports events. It is crucial for event organizers to identify their target group in order to make their event as much appealing.

Reeves' (cited in Hinch & Higham, 2004) classification of sports tourists is based on participation, non-participation, decision-making, and lifestyle. The latter is particularly important as it shows significance of particular event to someone's life. Events such as biker shows or marathons carry distinct cultures with them that many people identify themselves with. As will be seen later, cultural implications and identity are very significant parts of sports events, especially of smaller scale ones.

Thus, understanding the motivations that visitors hold towards their chosen sports or events is critical in staging sport tourism events. By knowing what motivates sport tourists, organizers will be able to define appropriate markets that their event is aiming at.

Understanding motivation is particularly important for small-scale events. Most of those events draw visitors from relatively close areas and, thus, are dependent on the revisiting people. Capitalizing on satisfying the needs of those customers will ensure their return. For example, Fyall, Callod & Edwards (2003) state that there are types of tourists who, in contrast to novelty seeking, are more likely to return to previously visited places.

Small-scale events and specifications of their visitors. Based on Hinch and Higham (2004) classification, sport tourism markets can be distinguished into active participation, event and nostalgia. However, such

market segmentation often overlaps as sport tourism often encompasses more than one market. Small-scale event can be seen not only in the context of event markets, but also in the context of active sport tourism markets (if it involves active participation), as well as nostalgia sport tourism (if it demonstrates parallels with cultural heritage).

Studies have shown (Green & Chalip, 1998; Green 2001) that oftentimes place or competition does not constitute fundamental attraction of the event. Events that carry distinct culture, which visitors identify with, are highly successful because of this bondage. As a result, Green (2001) suggests that event organizers should leverage this subculture and identity while promoting and staging event. Sports that have distinct culture (football) or highly specific movements, like bikers', bring more meaningfulness to event and its visitors, if properly organized. As Green concludes, not fostering this event augmentation can prove damaging to events' future success. For example, when fans were forbidden to make their half-time dance show and cheering, their interest in tournament has dropped (Green, 2001). In addition Green and Chalip (1998, p. 286) conclude, "the fundamental attraction is neither the place nor its people; the fundamental attraction is the other players who attend. The event itself is more important than the destination." The key concept for small-scale event organizers to recognize is the significance of distinct cultural value.

One of the potential groups that is in great demand of small-scale events are children, seniors, and disabled. Members of these market segments will never be able to attract large audiences, however, they do want to participate and have events. Masters games always attract great crowds of participants (Nike World Masters Games, 1998). And these visitors are very important, since most of them are retired people who are looking for attractions and traveling opportunities. Also, children like to participate in sports, while various tournaments are held to decide high school or junior club champions. More importantly, children will always be accompanied by their parents, which greatly increase the number of visitors. Event organizers have to bear this in mind and provide assisting visitors with additional amusements. Similarly approached should be events for disabled people. They are also surrounded by numbers of assisting people. With Paralympic movement gaining lots of attention and popularity, disabled physical activities have become very important and wide spread. As a result, there is great number of specific customer groups that are in need of sporting events that simply do not have to be large-scale.

Lastly, there are certain events (biker shows, field hockey) that carry certain cultural identities. People that are attached to this culture will attend those events and participation number might get very high. As was

mentioned before, such events represent lifestyle of most of their visitors. Iso-Ahola (cited in Hinch & Higham, 2004) explain that tourists seek to escape from their everyday lives. Example from Green and Chalip (1998) show that women in Flag football tournament were fascinated with an opportunity to play tough and rough game, be less feminine, and so on. White and White (2004) research showed that long-term journeyers choose to travel through Australian Outback because they, unlike in Europe, can get off the road anywhere and feel as 'a bunch of cowboys'.

As can be seen, large markets are available for small-scale event organizers. More importantly, there is a need from consumers for those types of events. Managers have to carefully assess the needs of customers and design an event to satisfy them. Small-scale event organizers have to target regular and dedicated sports tourist if the event involves active participation. Also, cultural issues have to be distinct, as well as traditions, family involvement that brings nostalgic feelings amongst participants.

Discussion

The present study showed several key issues regarding the development of sport tourism and events. Questions concerned about finding the right balance between commercialization and authenticity arose, especially within contemporary context of globalization. Hinch and Higham (2004) stress the need for strategic alliances and partnerships, while taking into consideration social, economic and environmental goals. The issue of such balance has been agreed upon and developed in terms of policy recommendations by the expert group on "Economic dimension of sport" (Recommendations …, 2016). We believe that in the context of small-scale events these same issues have to be addressed adequately.

As a result, planning of small-scale events needs to involve the assessment of commodification and authenticity, which refer to authentic nature of attraction. Some argue (Chhabra, Healy & Sills, 2003) that things lose their authenticity upon becoming commercialized. As a result, tourism could be seen as selling not real but 'staged' authenticity. Both globalization and partnership creation do not affect small-scale events as much as they do mega events. Mostly because of significantly smaller size of the event, its organizers do not have to be concerned with such complicated issues as large crowds of visitors with different cultural backgrounds, and all of them having different tastes and needs. Also, security concerns for small-scale events are not as demanding. Since mega-events involve participants from many countries (sometimes not the most friendly to each other), terrorist attacks have become an immense issue. Small-scale events do not have to

deal with so many contrasting issues. The main goal for small-scale events is to foster their distinct culture and bring together people that share it.

In this regard, small-scale events, especially those with distinct culture and participation attractions, could be seen as defying globalization. Those events and their 'own' unique culture are the keys to bringing participants together. It could be said that sport subcultures represent some form of 'counter culture'. As mentioned earlier, its members deliberately seek to distance themselves from the mainstream norms and practices of society. Tourists seek to escape everyday life and are looking for both authentic objects and authentic experiences. This is where events, and more importantly smaller scale events, have the advantage. As Chhabra, Healy and Sills (2003, p. 705) explain, "an authentic experience involves participation in a collective ritual, where strangers get together in a cultural production to share a feeling of closeness or solidarity." Here, we argue that sporting event, regardless of the attendee nature, will always be authentic. After all every sporting activity or spectacle inherently features uncertainty of the outcome, which provides unique and special aspect.

Lastly, it is worth drawing attention to the issues of strategic alliances and partnership. We believe that the importance of cooperative efforts is not as evident during small-scale events as it is during mega events. In their article on relationship marketing, Fyall, Callod and Edwards (2003) focused on long-term customer retention. They concluded that "relationship marketing is not a phenomenon that can be confined to one or two departments of an organization. The entire organization must be coordinated and must cooperate if the goals set are to be achieved" (p. 655). But with less traveling associated with small-scale events, less participants involved and so on, it is possible for one or few organizations to host an event rather than incorporate many different organizations.

As a result, it could be argued that organizers of small-scale events have to be more concerned with authenticity of the event rather than commercialization. Cultural distinction carries several advantageous merits that could be successfully leveraged. First, it offers distinct quality in terms of marketing and promotion of the event. Second, while already attending the event, the more visitors perceive attractions as being historical and authentic, the more they are willing to spend money.

Conclusion

Staging of small-scale events holds a significant part in sport tourism industry. Studies and practice have shown that even without great capacity, substantial financial contributions or high level athletic spectacle it is possible to stage profitable and prosperous small-scale event. The avenue to

success in staging small-scale should be paved upon studying visitors' motivations. Knowing what motivates travelers and how those motives differ among various groups of travelers, enables event organizers to create a product that best satisfies customer needs. Also, by acknowledging certain motives and targeting them event organizers can affect customer decision-making process.

Small-scale events should foster distinct culture and target specific groups that highly identify with event's cultural distinction. An opportunity for participants to escape everyday routine is one of the main traits that small-scale events offer. Also, active participation events offer physical challenges and abilities to test oneself.

By undertaking organization and development of small-scale events, organizers have to focus on authenticity of the event. Clearly authentic spectacle and experience is the main attraction for the visitors. In contrast to mega events, small-scale events involve ostensive participation from visitors. This close relationship should serve as a foundation for the organization of small-scale events.

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SCHORT COMMUNICATION

LACTATE – HARMFUL OR HELPFUL

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Abstract

The aim of this article is to assess the role of lactate in metabolic acidosis, muscle fatigue and exercise-induced adaptation. The view of the role of lactate has changed essentially during the last 30 years. Lactate is not considered as the main cause of fatigue as it had been previously, but instead as a marker of anaerobic catabolism of glucose. The lactate is produced also in aerobic conditions and is shuttled between cells. It serves as a major energy source, the major gluconeogenic precursor, as well as a signalling molecule that mediates exercise-induced adaptations.

Keywords: *acidosis, fatigue, lactate shuttle, lactate dehydrogenase, monocarboxilic transporters, signalling molecule*

Introduction

Lactate is known as the end product of anaerobic glycolysis, the catabolic pathway of glucose where two lactic acid and 2ATP molecules are produced. The history of lactate began when Carl Wilhelm Scheele isolated it from milk in 1780 and Jons Jacob Berzeliuss reported in 1808 that lactate was produced in muscles during physical load (Nalbandian and Takeda, 2016).

Lactic acid is a relatively strong acid, its pK=3.9. It dissociates in lactate anion (in short – lactate) and proton (H^+) immediately after its production and there is practically no lactic acid present in the cell at physiological pH values (Ferguson et al., 2018).

Formerly lactate was considered as waste product of glucose anaerobic metabolism without any positive function in the body. The accumulation of lactate – lactic acidosis – was considered to be the main cause of muscle fatigue during intense anaerobic exercises. A view of the

role of lactate and the causes of fatigue has changed essentially since the 1980s (Nalbandian and Takeda, 2016; Mederic et al., 2016).

The aim of this article is to assess the role of lactate in metabolic acidosis, muscle fatigue and exercise-induced adaptation

Metabolic acidosis is one of the causes of fatigue during intense anaerobic exercise. The pH drop in muscle cells from 7.0 to 6.2 reduces miofibrillar sensitivity to calcium ions. Other important causes of fatigue are depletion of ATP, it causes disruption of ion transport (sodium, potassium and calcium); and accumulation of inorganic phosphate (Pi), which forms insoluble calcium phosphates and reduces amount of calcium ions secreted from sarcoplasmatic reticulum and available for contraction (Fitts, 2016; Theofilidis et al., 2018; Westerblad, 2016).

New lactate paradigm determines that lactate is not a major cause of metabolic acidosis (Robergs et al., 2004). There is no biochemical support for this opinion. The real cause of metabolic acidosis is increased reliance on nonmitochondrial ATP turnover – ATP regeneration from glycolysis and phosphagen system. Proton is released when ATP is broken into ADP and Pi (Figure 1a). Proton releasing reactions are three reactions in glucolysis: 1st and 3rd reactions – phosphorylation reactions catalyzed by hexokinase and 6-phosphofructokinase respectively; and 6st reaction with $NADH+H^+$ formation. Thus two protons are produced per one pyruvate molecule produced.

a) $ATP + H_2O \longrightarrow ADP + P_i + H^+$

b) $CH_3-C(=O)-COO^- + NADH + H^+ \rightleftharpoons CH_3-CH(OH)-COO^- + NAD^+$

Pyruvate — Lactate dehydrogenase — Lactate

Figure 1. a) Hydrolysis of ATP; b) Lactate dehydrogenase reaction.

The production of lactate does not promote acidosis, rather the opposite – it retards acidosis and it reduces amount of protons in the cell. Firstly, production of lactate in reaction catalyzed by *lactate dehydrogenase* (LDH, EC1.1.1.27, and Figure 2b) consumes two protons. Biological significance of this reaction is to supply oxidized form of NAD^+ for continuation of glucolysis and prevention of pyruvate accumulation. Secondly, lactate facilitates removal of protons from cell; when lactate is transported together with proton out of cell with monocarboxylate transporters (MCT). Lactate must be considered as marker of anaerobic metabolism intensity, but not the cause of acidosis (Robergs et al., 2004).

Lactate shuttle theory was introduced in 1985 by George A. Brooks. He suggests that lactate is produced in fully aerobic conditions and is shuttled between producer and consumer cells. There lactate serves as a major energy source, the major gluconeogenic precursor, as well as a signalling molecule (Brooks, 2018).

Lactate dehydrogenase reaction is reversible – it can produce lactate by reduction of pyruvate or in the opposite direction: oxidize lactate to form pyruvate. The LDH is a tetrameric enzyme – it consists of four subunits. There are two types of LDH subunits: muscle subunit (M or LDH-A) and heart subunit (H or LDH-B). There are five LDH isoforms in the body: LDH-1 (4H); LDH-2 (3H+1M); LDH-3 (2H+2M); LDH-4 (1H+3M), and LDH-5 (4M). LDH isoenzymes with high content of M subunits (LDH-4 and LDH-5) are concentrated in fast twitch glycolytic muscle fibres, where they reduce pyruvate to lactate. But LDH isoenzymes with high content of H subunits (LDH-1) are found mainly in tissues with good oxygen supply: heart, brain, and slow twitch oxidative muscle fibres, where they oxidize lactate to pyruvate (Draoui and Feron, 2011).

Monocarboxylic acid transporters (MCT) transport lactate or pyruvate together with proton through membranes; this was reported by Halestrap and co-authors (Halestrap et al., 2004). MCT are membrane-integrated proteins that belong to 16th subgroup of solute carrier (SLC) proteins. SLC is a large group of transporters with 52 subgroups in total for transport of various ions as well as hydrophilic organic substances, charged and uncharged: amino acids, glucose (GLUT), ketone bodies, short chain (2-6C) fatty acids, and lactate and pyruvate. MCT are found in the cell membrane and in mitochondrial membranes. In total, 14 subtypes are known. Four MCT subtypes (MCT1-MCT4) transport lactate and pyruvate together with proton through membranes.

MTC4 is found in fast twitch muscle fibres and transports lactate out of the cell. MCT1 is the most common subtype. It transports lactate from blood to slow twitch muscle fibres and heart, where it oxidizes. MCT1 also transports lactate from blood to the liver (and to a lesser extent to the kidneys) where it is used as precursor for synthesis of glucose (gluconeogenesis). MCT1 also transports lactate out of the red blood cells, t-lymphocytes and cancer cells. MCT1 also transports ketone bodies from blood to skeletal muscles (Halestrap et al., 2004).

The major producers of lactate are fast twitch glycolytic muscle fibres, red blood cells, t-lymphocytes, but the major consumers of lactate are slow twitch oxidative muscle fibres. The heart and the brain are also active consumers of lactate. Oxidation of lactate provides up to 60% energy in the heart and 25% energy in the brain at increased lactate levels in the blood.

The heart muscle absorbs lactate from blood, but the brain cells take it from the adjacent cells (Ferguson et al., 2018).

Lactate is produced in fast twitch muscle fibres during exercise as well as rest and is transported with MCT4 out of the muscle cell to the intercellular environment or blood (Figure 2). MCT1 transports lactate from the intercellular environment or blood into slow twitch muscle fibres and other tissues, good supplied with oxygen: heart, brain, etc. When lactate enters the cell, it is converted (oxidized) to pyruvate by lactate dehydrogenase (LDH1). The pyruvate enters the mitochondria probably with MCT1 and is oxidizes in the Krebs cycle. Lactate shuttle between cytosol and mitochondria is reviewed by various authors (Hashimoto and Brooks, 2008; Rogatzki et al., 2015).

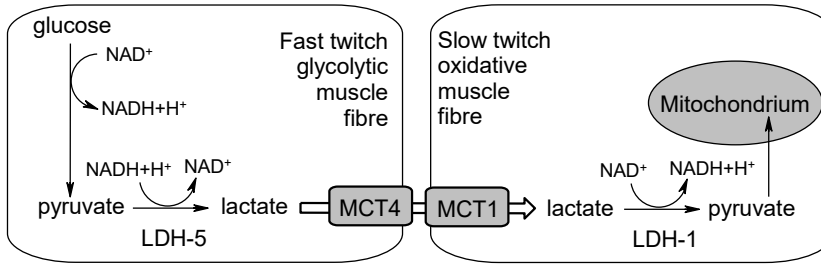

Figure 2. Lactate shuttle between fast and slow twitch muscle fibres (Draoui and Feron, 2011)

Lactate as signalling molecule. Increased concentration of lactate in a cell may induce changes in gene expression and mediate exercise-induced adaptations (Nalbandian and Takeda, 2016). Lactate mediates adaptations that increase the anaerobic glycolytic capacity (lactate production, transport, and metabolism). Lactate upregulates the intensity of glycolysis (phosphofructokinase activity), glucose transporters GLUT1, GLUT3 and GLUT4, LDH-A which converts pyruvate to lactate, and lactate transporter MCT4, but not MCT1.These effects are mediated by transcription factor *hypoxia inducible factor-1* (HIF-1). HIF-1 is known as the master regulator of oxygen homeostasis which regulates the expression of several genes favouring anaerobic ways of obtaining energy and stopping aerobic ones. The activity of HIF-1 is increased in glycolytic muscle fibres, particularly in response to high-intensity exercise (Nalbandian and Takeda, 2016).

Lactate can increase the level of one more transcription factor: *peroxisome proliferator activated receptor gamma coactivator 1-alpha* (PGC1-α). PGC 1-α mediated effects favour lactate aerobic catabolism: LDH-B is upregulated, which converts lactate to pyruvate; but LDH-A is downregulated; lactate transporter MCT1 is upregulated, which facilitates

uptake of lactate in slow twitch fibres, but it has no effect on MCT4. And it stimulates mitochondrial biogenesis.

In addition the lactate inhibits lipolysis by unknown mechanism. It stimulates muscle cell myogenesis during embryonic development, which may be important in muscle repair, maintenance, and growth (Nalbandian and Takeda, 2016).

As mentioned above, lactate is not the main cause of fatigue. Various authors have suggested that other important causes of fatigue are depletion of ATP and accumulation of inorganic phosphate. Hovewer, it has been suggested that also intracellular accumulation of H^+ ions, extracellular accumulation of K^+ ions, reactive oxygen species (ROS), heat shock protein (HSP) and orosomucoid (ORM) also affects muscle fatigue (Wan et al., 2017). As the article is about the role of lactate, the other causes of fatigue are not discussed in detail.

Conclusions

A view of the role of lactate has changed essentially during the last 30 years. Lactate is not the main cause of fatigue. It may be considered as a marker of glucose anaerobic catabolism. The lactate is produced also in aerobic conditions and shuttled between cells. It serves as a major energy source, the major gluconeogenic precursor, as well as a signalling molecule that mediates exercise-induced adaptations. Coaches and other sports specialists should be introduced to these facts and theories about the role of lactate and should apply this information in their coaching and teaching practice.

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Content

Research or project reports, case studies of practice, action research reports, and reports on teaching practice or techniques will be accepted.

Research reports should include a description of the practical application(s) of the ideas tested, while reports of teaching practice or techniques should contain an explanation of the theoretical foundation underlying the practice or technique in question.

Material in the form of illustrations or photos is welcomed. This material should be accompanied by text clearly setting out its philosophical or practical origins or implications. All material should be clearly referenced to its sources.

Arrangement

The manuscripts should be arranged as follows: title page, abstract and body text

Title page should contain: title of the paper, first and last names of authors with affiliation, first and last name of corresponding authors with postal address, telephone, fax and e-mail.

Abstract (up to 250 words) consisting of the following sections: justification and aim of the study, material and methods, results, conclusions, as well as 3 – 6 key words, should be provided before the body text.

Body text should be sectioned into: Introduction, Material and Methods, Results, Discussion, Conclusions, Acknowledgements (if necessary) and References. In articles of others types, the text should follow in a logical sequence and headings of its particular sections should reflect issues discussed therein.

Introduction – should be short and concise; it should introduce readers into research problems addressed in the study as well justify undertaking the research and specify its aim.

Material and methods – should describe the subject of the study (in the case of human subjects data should include their number, age, sex and any other typical characteristics) and methods applied in a sufficiently exhaustive way to enable readers to repeat the experiments or observations. For generally known methods only references should be given, whereas detailed descriptions are to be provided for new or substantially modified methods.

Results – should be presented in a logical sequence in the text, tables and figures. Data collated in table and figures should not be repeated in the text which should summarize the most important observations.

Discussion – should emphasize new or important aspects of experimental results and discuss their implications. Results of own studies are to be compared with findings described in the respective domestic and international references used by the Authors.

Conclusions – should be started in points or descriptively and should be logically connected with objectives stated in the *Introduction*. Statements and conclusions not derived from own observations should be avoided.

Author's declaration on the sources of funding of research presented in the scientific article or of the preparation of the scientific article.

References

References should follow the instructions for Authors on References (APA style).

This document describes standards for preparing the references in the APA style.

Citing in-text. Following artificial text shows different types of in-text citation:

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Claessens (2010) found evidence that attention will be given to multi-compartment models, such as the 3-water, 3-mineral and 4-compartment models, to assess percentage of body fat. However, Raslanas, Petkus and Griškonis (2010) noted that Aerobic physical load of low intensity got 35.1 % of total trainings time. Research on physical loading also focused on identifying the basis of many years' research of physical activity (Bytniewski et al. 2010). According to Ezerskis (2010), "… heavy physical loads had the undulating character depending on the dynamics of workloads…" (p. 71) yet girls are more ascertained that the Track & Field training helps to develop courage.

Instructions for Authors on References (APA style)

Please provide all the required elements in the references to your paper. Please pay particular attention to spelling, capitalization and punctuation. Accuracy and completeness of references are the responsibilities of the author. Before submitting your article, please ensure you have checked your paper for any relevant references you may have missed.

A complete reference should give the reader enough information to find the relevant article. If the article/book has DOI number, the author should include it in the references. And most importantly, complete and correct references may allow automatic creation of active links by the MetaPress technology that we use for making the electronic version of our journal. Active reference linking is regarded as the greatest benefit of electronic publishing and it adds a lot of value to your publication.

Additional information about APA style writing is found on LASE web page: http://www.lspa.lv/ .

Tables – should be prepared on separate pages (saved in separate files) and numbered using subsequent Arabic letters. They should be provided with titles (above). Every column in a table should have a brief heading and more extensive explanation should be given under the table, e.g. statistical measures of variability.

Figures – should be prepared in an electronic form and saved in separate files. A separate page should be provided with legends to figures, authors' names, manuscript's title, and consecutive number of figure with "*bottom*" or "*top*" identification. Photographs or other illustrative materials may be submitted in an electronic form (*.tif, *.jpg, image resolution: 300 or 600 dpi) or any other form suitable for final technical typesetting by the Editorial Office. In the appropriate places in the text consecutive numbers of tables or figures should be provided in parentheses, e.g. (Tab. 1) or (Fig. 1).

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Submission of manuscripts

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